

PUBLIC'S PERCEPTION OF MOBILE COMMUNICATION AND THE ASSOCIATED HEALTH HAZARD

**THE RELATION OF KNOWLEDGE, BELIEFS, AND AFFECTIVE
EVALUATION TO PEOPLE'S HEALTH CONCERNS**

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by

Marie-Eve Cousin
of Concise (VD)

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Prof. Dr. Michael Siegrist and Prof. Dr. Heinz Gutscher

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Summary

On the one hand, the use of cell phones is a part of our daily life and provides numerous benefits. On the other hand, some people are confused and concerned about the rumored health effects of electromagnetic fields (EMF) emitted by mobile communication. Base station siting in occupied areas has turned out to be an especially conflictive process. The ubiquity of mobile communication and the prospect of an increasing number of base station siting conflicts prompts politicians and scientists to gain a better understanding of why people experience such ambivalent cognitions and feelings toward this technology.

The aim of the present thesis was to explore what kinds of mental models people have in regard to mobile communication and the associated health hazard. People's beliefs, knowledge structures, and common misconceptions were assessed by a combination of qualitative and quantitative steps known as the 'Mental Model Approach' (Morgan *et al.*, 2002). It is hoped that the results obtained provide a basis for a better understanding of laypeople's risk perception in the domain of electromagnetic fields. The research project underlying this thesis was guided by the aim of identifying people's information requirements for developing adequate beliefs of the nature and magnitude of the potential risk.

The first research step included in-depth interviews with various experts, unconcerned laypeople and base station opponents. Expert interviews and literature research were used to construct an authoritative model that identifies the relevant aspects of the field and provide a basis for structuring lay interviews. The comparison of expert and lay models showed what kinds of

misconceptions exist and most seriously hamper the understanding of the potential hazard.

A representative survey highlighted the prevalence of knowledge and misconceptions in the general population. Results confirmed the qualitative insights. People lacked knowledge about the interaction patterns of cell phones and base stations, and they misjudged the resulting exposure magnitudes. In addition, these misconceptions were shown to influence people's base station siting preferences. People opted for base station siting outside occupied areas, but this would result in higher exposure for cell phone users. From a public health perspective, it is important, therefore, to provide people with adequate information about the consequences of this choice.

Besides their technical knowledge, people's health concerns and health beliefs were assessed in the survey. Compared with environmental hazards, such as air pollution and ultraviolet rays, mobile communication evoked less health concerns. Within the mobile communication, however, base stations provoked more worries. Health beliefs were found to vary considerably across respondents and were related to health concerns. The occurrence of electromagnetic hypersensitivity (EHS) was judged possible by about two thirds of the respondents. In addition, non-scientific beliefs shaped people's health concerns. In sum, the insights obtained provide guidelines for communicators who want to know what concepts should be explained and what questions should be answered for effective risk communication within the context of mobile communication.

Reflecting the 'Mental Model Approach,' a methodological aspect deserves mention. Besides the identification of the factual knowledge elements, the applied methodology was helpful in understanding what kinds of social processes and social perceptions are involved when it comes to conflicts about new base station siting projects. These insights were not fully exploited in the present thesis, but, in addition to the cognitive aspects, a range of affective influence factors related to information processing was explored. The influence of prior beliefs on people's confidence in new information was experimentally studied. It was found that new information is trusted more when it is consistent with already held beliefs. These results help to explain why concerned people are difficult to convince with new facts about the harmlessness of mobile communication radiation. In a more general sense,

attitudes toward technological hazards were measured by implicit association tests (IAT). Results showed that this method revealed negative attitudes that traditional questionnaires did not detect and that more knowledge did not necessarily influence people's implicit positive or negative attitudes.

In summary, both cognitive and affective processes take part in people's intuitive understanding of the nature and magnitude of possible EMF risks. Both types of processes, and particularly their interrelation, deserve closer attention.

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Chapter I

General Introduction in the Research Field of Risk Perception and Mobile Communication



1 Introduction

Human curiosity and creativity lead to a multitude of innovations and technical progress. Innovations like letterpress, electricity, and memory chips profoundly changed our daily life. Some of these innovations and technologies, in addition to their benefits, also bear various immediate and delayed risks. Even if the benefits of a technology for a society are overwhelming, not all people are willing to accept the accompanying risks. In cases like nuclear energy and GMO, the risk assessments of responsible experts and the perceptions of the public may differ significantly and lead to enduring controversies. Public rejection of technologies considered to be promising by experts was one starting point of widespread research activities aimed at understanding human risk perception and its consequences for decision-making.

This dissertation project examines one of these contentious technologies – mobile communication. Despite the fact that 87% of the Swiss population over 16 years own a cell phone (GFS, 2007), some people are alarmed when it comes to siting a new base station near their living area (Asendorpf, 2002; Burgess, 2004). The reasons for rejection of new base stations may be various: People may be worried about the scientific uncertainty in regard to adverse health effects of radiofrequencies (RF). Lack of knowledge or distrust of industry and regulators may cause the refusal. Also ‘not in my backyard’-tendencies, which were observed in other facility conflicts, such as nuclear waste disposal and power transmission lines, may play a role (e.g., Freudenburg & Pastor, 1992; Hunter & Leyden, 1995; Marks & von Winterfeldt, 1984).

Given the fact that increased demand and technology changes (introduction of the 3. Generation Network: 3G/UMTS) will increase the number of necessary base stations in the next decades, the number of potential conflicts will probably increase as well. Therefore, it is important to acquire a better understanding why people fear cell phone base stations but not their cell phones. In other words, the key question is: why do people reject a part of the necessary infrastructure that allows them to benefit from their beloved cell phones?

The present dissertation explores the mental models of laypeople in regard to mobile communication. The insights gained about laypeople's knowledge and beliefs may help to improve further communication.

The present introduction (Chapter I) provides background information to the dissertation project. First, key terms related to risk perception are introduced, and their relevance for the field of mobile communication is discussed. Second, the relevant technical and social aspects of mobile communication are presented. Third, an overview of the research field 'Risk Perception of New Technologies' is provided. At the same time, the acquired insights concerning risk perception of mobile communication are briefly presented. This way of proceeding allows the identification of relevant knowledge gaps in regard to risk perception of mobile communication. Finally, the resulting research questions are presented, and the applied methodology is briefly outlined. In addition, an overview of the remaining Chapters is provided.

2 No Smoke without a Fire? – Is there a Health Risk or just an Uncertainty?

As shown by various studies, experts and laypeople understand different things by the term 'risk' and differ, therefore, in their risk perception (e.g., Bostrom, 1997; Flynn & Slovic, 1999; Gardner & Gould, 1998; Slovic, 1987, 1999; Sjöberg, 1998). Laypeople may include in their mental assessments qualitative risk characteristics like catastrophic potential, voluntariness of exposure, and controllability, whereas experts may focus more on quantitative facts like severity of harm and probability. Or, in the words of Bennett (1999, pp. 14) "scientists usually define risk in terms of effects on populations, while the lay audience is concerned with effects on individuals." Therefore, it is important to clarify the key terms for the present thesis. Rosa (1998, pp. 28) defined risk as follows: "Risk is a situation or event in which something of human value (including human themselves) has been put at stake and where the outcome is uncertain." Risk perception, on the other hand, means "people's beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits" (Pidgeon *et al.*, 1992, pp. 89). Risk per-

ception, according to this definition, is multidimensional, situational, socially constructed, and depends on one's values (cf. Slovic, 1999).

Conflicts regarding new technologies are often due to differences in acceptability assessments of well-known risks or due to (scientific) uncertainty about the possible consequences of a new technology. In the case of mobile communication, it is the scientific uncertainty about the possibility of adverse health effects below the international exposure standards that causes discussion among experts as well as among responsible authorities, mobile communication providers and the public. To put it simply, experts discuss the uncertainty in the field, whereas laypeople perceive risks to their health. The controversy is probably also due to human's difficulties in handling uncertainty in scientific knowledge (e.g., Johnson, 2003; Johnson & Slovic, 1995, 1998). Most laypeople would prefer to have clear 'yes-or-no-answers' to their health questions about mobile communication, but science unfortunately is not able to provide this kind of answers yet. Numerous scientific boards have tried to summarize the wide scientific evidence and provide understandable risk assessments (e.g., Hug *et al.*, 2007; IEGMP, 2000; WHO, 2002; Valberg *et al.*, 2007). The consensus of all these literature reviews is that there is actually no scientific evidence for health effects below the international exposure standards, but that effects due to long-term exposure cannot be ruled out yet. This conclusion does not seem to decrease people's concerns. On the contrary, they adopt a risk assessment that can be described as "No smoke without a fire!" and call for more protection against EMF. In such difficult situations, risk communication may be put into action to work toward a consensus between the involved parties. According to the U. S. National Research Council (NRC, 1989, pp. 21), risk communication is "an interactive process of exchange of information and opinion among individuals, groups and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risks, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management."

The present thesis explores the relations between laypeople's risk perception and risk communication. It aims to learn more about people's understanding of risk, uncertainty, and health effects in regard to mobile communication. Therefore, people's knowledge and belief structures (i.e. mental models) are systematically explored.

3 The Case of Mobile Communication

The topic of mobile communication and the related controversies has attracted the interest of various disciplines. To follow these research lines it is important to understand basic facts and the main disputes in the field. The present section characterizes mobile communication and its peculiarities as well as its relevance for society. A comprehensive discussion of all technical, regulatory and political aspects is beyond the scope of this introduction. Therefore, the following paragraphs give a brief overview about the most relevant aspects of the topic. Interested readers can find additional technical details in Chapter II and extended information in the cited literature (e.g., technical, regulatory, and political information: BAG, 2007; Berz, 2003; BUWAL, 2005; Del Pozo & Papameletiou, 2005; Rösli & Rapp, 2003).

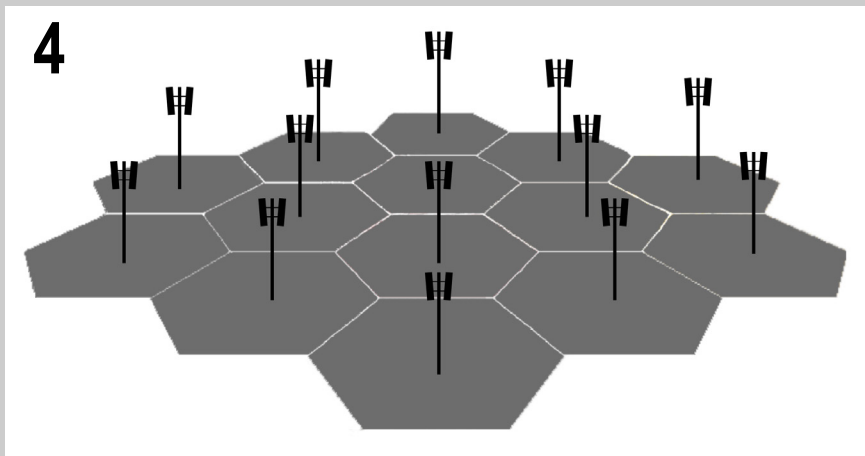
3.1 What is Mobile Communication?

To put it simply, mobile communication uses electromagnetic fields (EMF) to transport information from one participant to another participant through the air. To make this possible, individual hand devices (cell phones) and a network consisting of base stations are necessary. The base stations provide geographical coverage over areas known as ‘cells,’ but both devices, cell phones and base stations, act as antennas (to receive information) and as senders (to post information). Therefore, cell phone users are always exposed at least to the EMF of their cell phone and the EMF of the connecting base station (see Table 1.1 and Box 1.1 for more information).

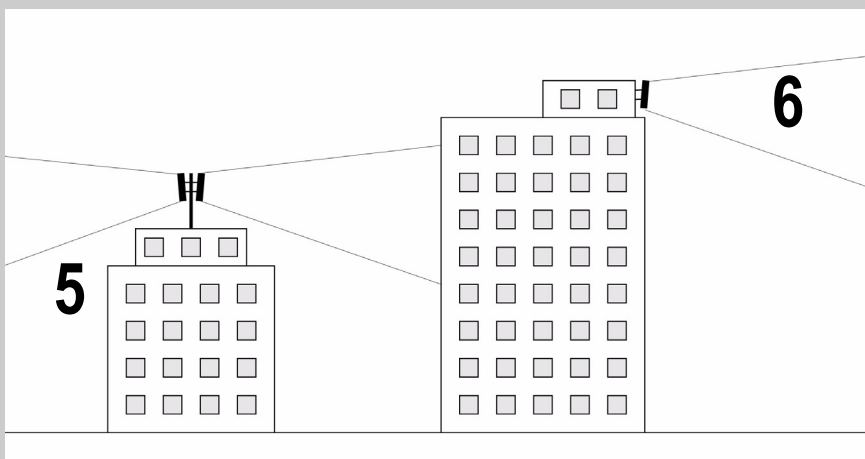
Box 1.1: Base Stations and Cellular Networks



Mobile communication operates through **cellular networks (4)**. In general, a base station consists of several **sector antennas (1)** and covers a cell, which is a restricted geographic area. The **transmission dish (2)** is used for 'line of sight' communications with the rest of the network and its computerized call exchange systems. Antennas can be very small and blended into the facade of a house (3).



The size of a cell depends on customer call usage in a geographical area and also on the physical terrain. Each base station can only handle a specific number of calls. If customer usage consistently exceeds this capacity, more base stations would be needed. This is why urban areas have greater base station density.



The sector antennas beam RF energy in **specific directions**. The RF energy directly below an antenna is very low (5). RF waves decrease rapidly as they travel away from the antenna. Exposure limits may only be reached in parts of the **main lobe (6)** of an antenna.

Table 1.1. Comparison of cell phone and base station properties (GSM)^a

	Mobile Communication Devices	
	Cell Phones	Base Stations
Qualitative characteristics	Great immediate benefit, exposure is voluntary and controllable, technology is familiar through daily use	Benefit less obvious, only when it does not work, exposure is involuntary and not controllable, technology is less familiar
Radiation patterns (GSM)	Cell phones that are switched on respond to specific control signals from the nearest base station (ca. every 15 min). In between, the phone remains dormant until the user makes or receives calls. Cell phones have an automatic power control which reduces the transmitted power to the minimum possible.	To avoid interfering with other antennas, an antenna operates with the lowest power level necessary to provide good communications. One channel (the control channel) from each base station is always transmitting with a constant power, regardless of the traffic intensity. Other channels (traffic channels) send only when the traffic requires, and may also use a power regulation system.
Emission increases when...	... connection to the next base station is weak ... the user is traveling and therefore changing the cells (handovers force the cell phone to radiate with full power for a short moment) ... the calling user is moving from outside to the inside of a house (ca. 68% more radiation)	... many users make simultaneous calls ... the connection to the cell phones is weak (e.g., the user is far away, inside a house or inside a car)
Average emissions	GSM: 120-240 mW (BAG, 2007)	lower than 1 V/m (Lehmann <i>et al.</i> , 2004)
Max. Power:	GSM 900: 1W GSM 1800: 2W	The power varies between a few Watts to over 1000 Watts EPR (effective radiated power)
Exposure limits	They need to meet the CENELEC product standard EN SN 50360 (CENELEC, 2001a, b), which is based on the ICNIRP emission standard of 2 W/kg (ICNIRP, 1998).	Max. exposure: GSM: 41-58 V/m Sensitive areas: (apartment, school, office): GSM: 4-6 V/m
Regulated by ...	CENELEC (2001a, b). EN SN 50360 product standard	NISV (1999)

a. Sources: Rösli & Rapp (2003); MMF (2005)

The frequencies used by mobile communication are located in the spectrum of high-frequency electromagnetic fields. Actually there are GSM (2. Generation) and UMTS (3. Generation) networks available in Switzerland. Other technologies that operate with the same type of radiation are radars, radio- and television broadcasting channels, baby phones, and microwave ovens (see Figure 1.1).

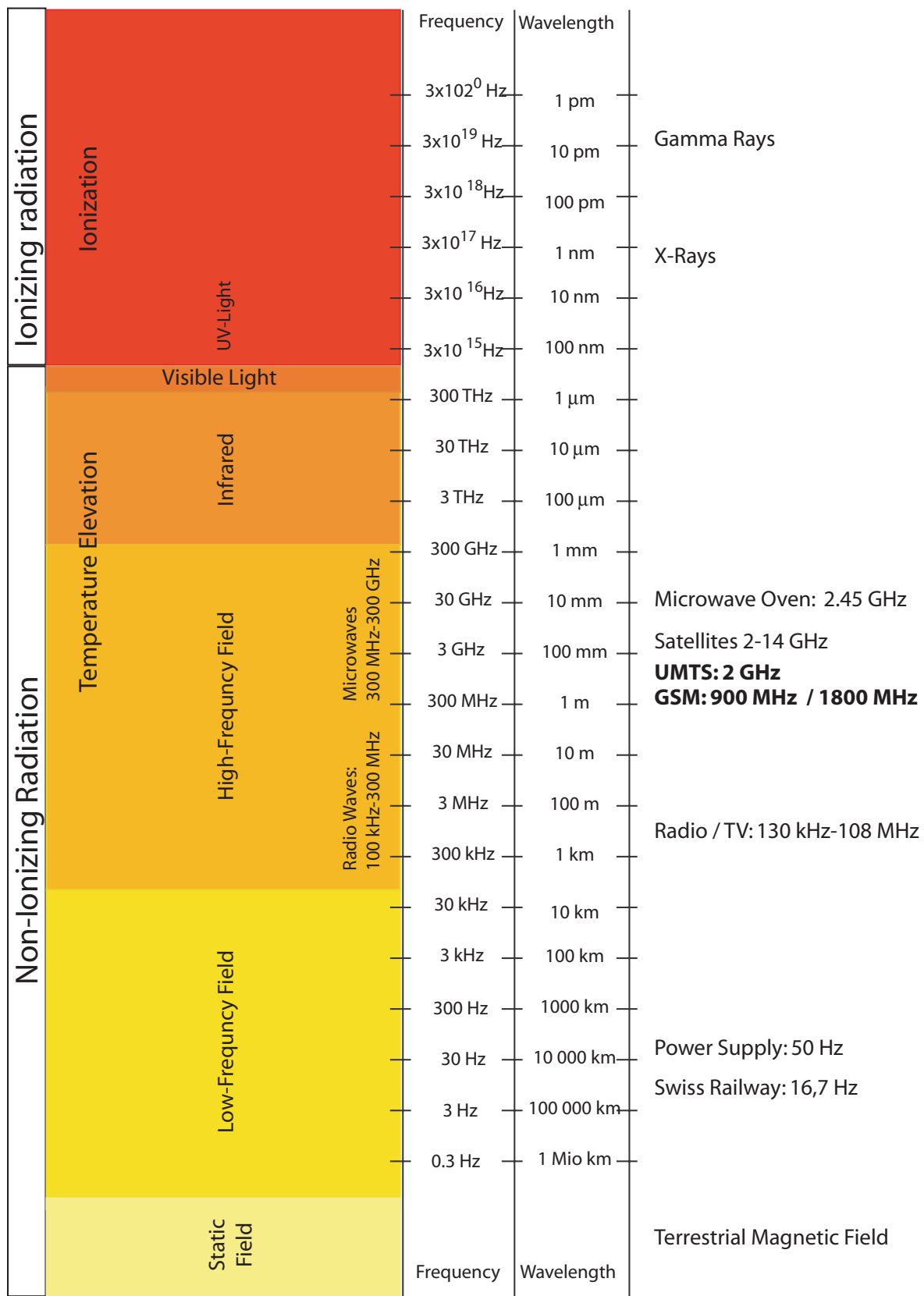


Figure 1.1. Electromagnetic spectrum and examples for appliance. Data source: Berz (2003, pp. 23)

The frequencies up to 300 GHz are also called ‘non-ionizing radiation’ because their fields are too weak to break the bonds that hold molecules in cells together (WHO, 2002, pp. 1). Ionizing radiation, such as gamma rays given off by radioactive materials and X-rays, can induce these cell changes and are therefore known to cause cancer and other adverse health effects. However, besides the EMF frequency, the magnitude or strength of a field may be relevant for health effects.

3.2 Historical Review: Humans’ Health Concerns about EMF and Regulation Approaches

Concerns about the health consequences of human-made electromagnetic fields are as old as the fields themselves. Already in the late 1800s the topic attracted scientific interest but received particular attention during the last 30 years (BUWAL & BFS, 2002, pp. 190-191; Müller, 2000; WHO, 2002, pp. 1). The topic received broad public attention in connection with reports about high voltage power transmission lines and childhood leukemia (Brain *et al.*, 2003; Hester, 1992). The introduction of microwave ovens and the increasing number of computer workplaces also contributed to public awareness of ‘electrosmog’ in daily life. In Switzerland, a controversy (starting in the 70s) about the shortwave transmitter station of Schwarzenburg (Bern) attracted public attention to health effects caused by high-frequency EMF. Consequently, an association for people suffering from electrosmog called ‘Gigahertz’ (Schweizerische Interessengemeinschaft Elektrosmog-Betroffener) was founded. Today, this association also addresses questions in regard to EMF emitted by mobile communication (e.g., Jakob, 2004).

Mobile communication networks have been available in Switzerland since 1978. As shown in Figure 1.2, the broad diffusion of this technology started around 1998 with the liberalization of the telecommunication market and the market entry of various mobile communication providers (Swisscom, the former state monopoly Telecom PTT and Sunrise, former diAx, in 1998; Orange in 1999). The number of mobile communication users increased from 1,133 in the year 1978 to over 7 millions in the year 2006 (BAKOM, 2007).

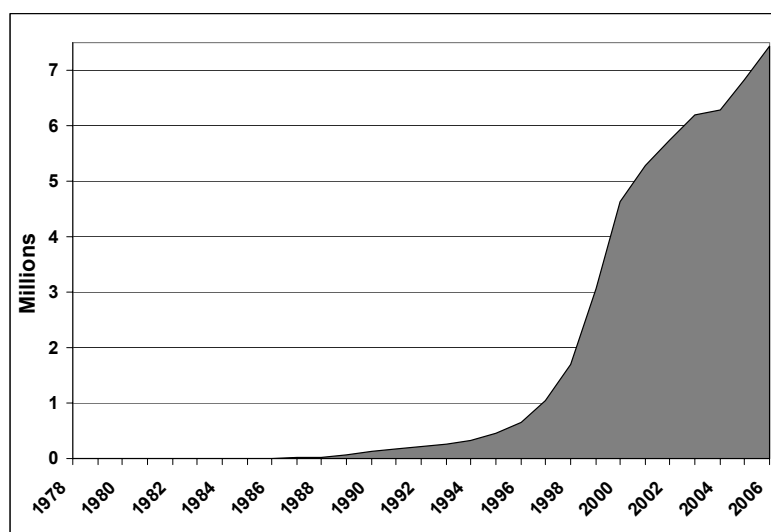


Figure 1.2. Mobile communication users in Switzerland, 1978-2006 (without pre-paid users). Data source: BAKOM (2007)

The possibilities offered by mobile communication influenced communication habits, daily life, and brought about a wide range of new social and economic possibilities (e.g., Law, 2005). For example, users benefit from increased personal safety (e.g., outdoor sports), better access to emergency services (e.g., elderly people living alone), access to vital information wherever they are (e.g., email, Internet), and more flexible work and life patterns. Today, the mobile communication industry provides over 30,000 jobs in Switzerland (Vaterlaus *et al.*, 2004).

The continuing success of mobile communication increases the demand for more transmission facilities (see Figure 1.3). In addition, new transmission technologies (UMTS, 3. Generation) operate with small cells and need more base stations to guarantee the services. Therefore, the number of needed base stations will continue to increase. As seen in the past, the siting of new base stations can be problematic (Burgess, 2004, 2002). Some concerned people react with reservation to new base station siting projects, especially when they are planned in or near living areas. People are worried about the scientific uncertainty in regard to adverse health effects and question whether the existing exposure regulation provides them enough safety.

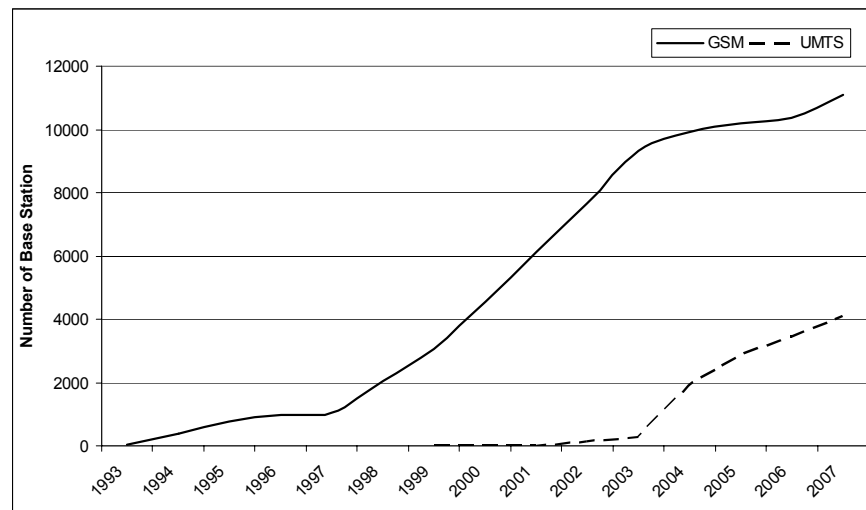


Figure 1.3. Number of GSM and UMTS base stations over 6 Watt ERP in Switzerland (1993-2007). Data source: Thomi (2008)

Every country is free to set its own national standards for exposure to EMF. The majority of the countries based their standards on the guidelines set by the ‘International Commission on Non-Ionizing Radiation Protection’ (ICNIRP), which acquired recommendations based on the available peer-reviewed scientific literature on short-term acute exposure (see for details ICNIRP, 1998; WHO, 2002, pp. 51-57). Results on long-term exposure are not available yet and, therefore, not considered in the recommendations. This point is often criticized in debates about exposure standards (e.g., Jakob, 2004).

Based on the precautionary principle embodied in the Swiss Environmental Protection Act (EPA, 1983, SR 814.01, sec. 1 p. 2, [Umweltschutzgesetz, USG]), Switzerland set exposure limits to a factor of ten for the so-called ‘sensitive areas’ (NISV, 1999). In addition, the responsible authorities constantly monitor the results of new scientific studies in order to adjust the exposure limits if indicated (Del Pozo & Papameletiou, 2005).

3.3 Main Discussion Points and Controversies

There are many issues that stimulate discussions about mobile communication EMF and health. The present section gives an overview of frequently mentioned discussion points among experts as well as contents of public debates:

Methodological difficulties: A fundamental question in the health research is: “Which exposure, which dose of RF is necessary to cause adverse health effects?” Therefore, the question of exposure assessment (estimation) is essential for all epidemiological as well as experimental studies (Röösli & Rapp, 2003, pp. 45-46). For example, in epidemiological studies the exposure differences between individuals or groups are extremely difficult to assess. People are simultaneously exposed to a variety of RF sources in constantly varying strengths (e.g., radio and television broadcasts, wireless LAN, mobile communication). Also, other geography-related confoundings must be considered (e.g., hazardous waste facilities). An effect assessment of radiation emitted by mobile communication alone is hardly possible. In practice, researchers try to resolve this problem by developing so-called dosimeters, which are portable devices that register the radiation of multiple frequencies to which the individual is exposed to (e.g., SNSF, 2007). Some controversial studies failed to meet the required quality standards of exposure assessment and their conclusions, therefore, are questionable (e.g., Hug *et al.*, 2007, pp. 132-133).

Disagreements among experts: Experts disagree mainly about two points (Schütz & Wiedemann, 2005): They disagree about the extent and the relevance of uncertainties in the scientific knowledge¹ and whether precautionary measures should be implemented or not. The expert debate is centered on whether long-term, low level exposure below the exposure limits can cause adverse health effects or influence humans well being (WHO, 2002, pp. 5). Mobile communication is a relative young technology. Therefore, based on currently available scientific studies, the consequences of long-term exposure are not yet foreseeable. Further research is needed. In addition, the precautionary principle is variously defined and interpreted (IWG, 2003; Kheifets *et al.*, 2000).

Diverse preferences for precautionary measures and base station siting: As with experts, laypeople and base station opponents express varied

1. “Scientific uncertainty results usually from five characteristics of the scientific method: the variable chosen, the measurements made, the samples drawn, the models used and the causal relationship employed. Scientific uncertainty may also arise from a controversy on existing data or lack of some relevant data. Uncertainty may relate to qualitative or quantitative elements of the analysis.” (European Communities, 2000, pp. 14)

preferences in regard to precautionary measures. This can include the siting of base stations as well as exposure standards. For example, some groups claim to follow the standards known as ‘Salzburg limit’ (exposure value of 1 mW/m^2). In 2000, critical scientists formulated exposure recommendations that are about 9000 times lower than the ICNIRP recommendations (Oberfeld, 2000). Other concerned citizens do not agree with the legal foundation of base station siting. Legal foundations (Land Use Regulation Act [Raumplanungsgesetz, RPG, 1978]) dictate that base stations have to be sited where they are needed within the limits of building areas. Base stations outside of building areas need a special authorization. Therefore, base station opponents object that landscape protection is more highly valued than protection of the population (e.g., Jakob, 2004). Other reasons for rejection are visual amenities or worries about the impact of base stations on house prices.

Electromagnetic hypersensitivity: Some people report suffering from electrosmog and demand EMF-free areas to permit them a normal and painless life. According to Leitgeb and Schröttner (2003, pp. 387) electromagnetic hypersensitivity (EHS) denotes the development of health symptoms due to an exposure to EMF. Studies in various countries showed that about 5% of the respective population report health complaints that they attribute to EMF exposure (e.g., Rösli *et al.*, 2004; Schreier *et al.*, 2006; Seitz *et al.*, 2005). Actually, there is no scientific evidence for the existence of electromagnetic hypersensitivity concerning RF. Nocebo effects and other explanations are discussed among experts. However, people suffering under EHS deserve to be taken seriously, with an effort to understand their suffering.

4 Public Perception of New Technologies

The traditional research field of risk perception of new technologies can be divided into several related areas. Figure 1.4 gives a simplified overview of the different areas of research that are addressed in the present outline of the theoretical and research background (see for other overviews, e.g., Flynn, 2007; Pidgeon *et al.*, 1992, pp. 89-118; Taylor-Gooby & Zinn, 2006). The following summary provides some additional explanation to Figure 1.4. References can be found in the according paragraphs.

The overview covers a psychological and an individual-based analysis (e.g., content of the ‘black box:’ cognition, affect, and individual differences) as well as an analysis that focuses on social or interactive processes and their role for risk perception and risk behavior (social dynamics, cultural and societal influences). The elements listed interact in various ways that cannot be fully depicted here.

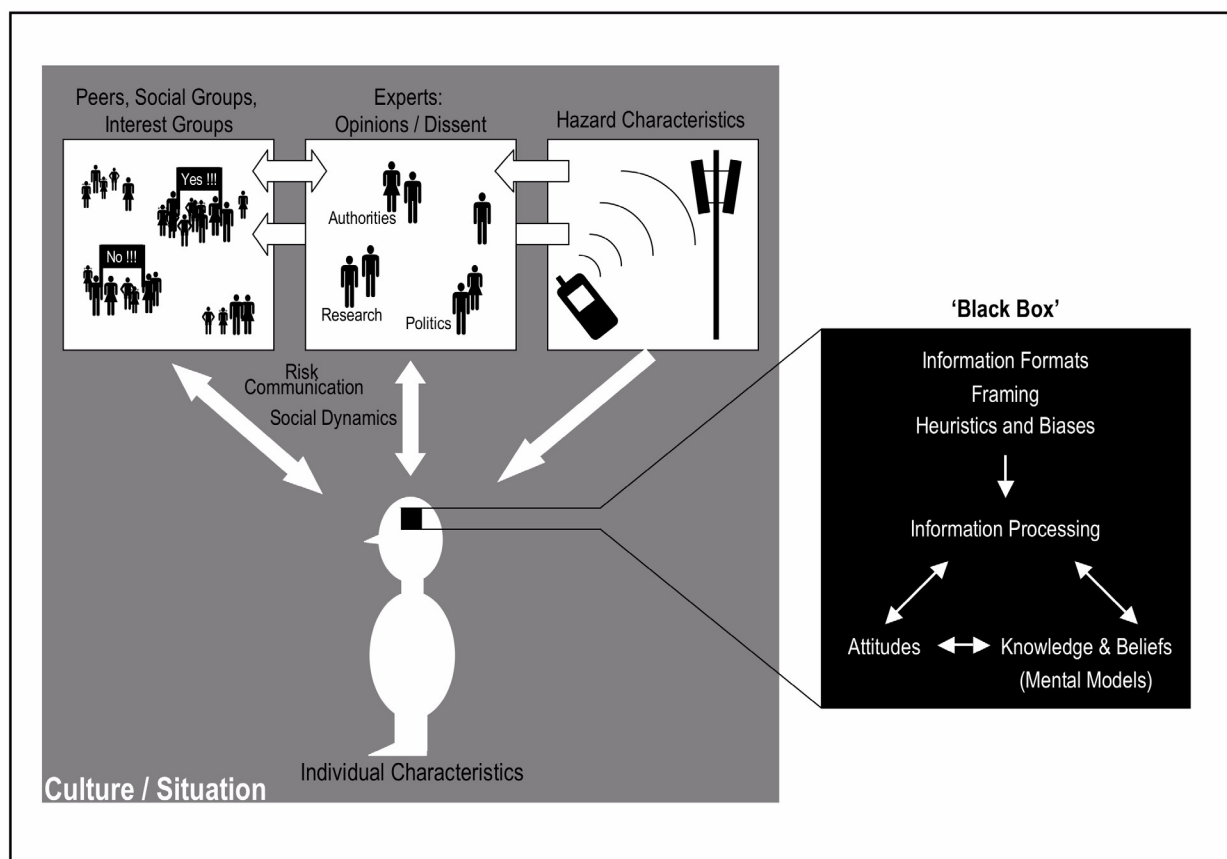


Figure 1.4. Overview about theoretical background and research areas of risk perception of new technologies

The main aspects are the following: An individual's perception of a given technology or hazard is influenced by the perceived **hazard characteristics** and the perception and availability of information of ‘significant others.’ The ‘significant others’ might be **experts** who possess relevant knowledge or authority important for societal decision-making. The experts are rarely a homogenous group. For nearly every topic experts differ in their opinions or risk assessments. Therefore, the individual is exposed to various opinions as well as to dissent among experts. In addition, **peers, social groups, and**

specific interest groups provide different information and opinions about a given technology or hazard.¹ The media are a special interest group that documents events, directs people's attention to certain issues, and allows the involved actors to express their differing views. Such ambiguous situations raise the issue of trust in information providers. Previous research linked trust to various **societal interactions**, such as **risk communication**. In the present overview, trust is discussed in the paragraph about **individual and cultural characteristics**, with a full awareness that trust might be discussed under all other paragraphs as well. The afore-mentioned societal interactions take place in **culture and context** that may influence various aspects like values and attitudes. Finally, information processing, influenced by the environment and personal experiences, takes place in the human '**black box**.' Some of the mechanisms and processes in the human 'black box' were revealed by research and are, therefore, printed in white. Heuristics, biases, framing, and information formats are related to external factors that are shaped by information presentation. Besides these factors, attitudes, knowledge, and beliefs (e.g., mental models) are known to influence one's (risk) perception. The precise interactions are not yet clear, and are under scientific investigation. Current psychological practice adopts the assumption that new information is interpreted upon the basis of organized knowledge structures by which all individuals make sense of the world (Pidgeon *et al.*, 1992, pp. 98). Not explicitly shown in the black box, information processing consists of cognitive, affective, and intuitive processes.

Accompanying the following general research outline, reflections and research results in regard to mobile communication are provided in separate info boxes in the paragraphs below. Thus, the reader can easily access the current research status of psychological research concerning mobile communication.

4.1 Characterization of New Technologies and Hazards

Research activities in regard to the acceptance and risk perception of new technologies started in the late 1960s. Public rejection of certain technologies, considered promising by experts, evoked the question of an optimal

1. Please note that experts are also spit into interest groups. Furthermore, one may struggle with the definition of experts and their demarcation from counter-elites.

balance between risks and benefits (Fischhoff *et al.*, 1978; Starr, 1969). Researchers began to identify the external factors and cognitive mechanisms that influence risk perception (e.g., Kahneman & Tversky, 1972, 1973; Tversky & Kahneman, 1974; Slovic *et al.*, 1977).

An influential approach called the psychometric paradigm addressed the problem of “what people mean when they say that something is (or is not) ‘risky’” (Slovic, 1987, pp. 280). Based on multivariate analysis of a wide range of activities, technologies and natural hazards, two (or sometimes three) factors were extracted from various qualitative characteristics: ‘dread risk’ and ‘unknown risk.’ The factor ‘dread risk’ comprises several dimensions, such as uncontrollability, dreadfulness, catastrophic potential, threat to future generation, involuntariness, and was shown to be the most influential determinant of risk perception (Mullet *et al.*, 1993; Slovic, 1987; Teigen *et al.*, 1988).

The psychometric paradigm has been applied in various studies (see Box 1.2) and has showed consistent results (overview in Slovic, 1992, 2000, pp. xxv-xxvi). However, it was also criticized for being based on aggregated data and for neglecting inter-individual differences in risk perception (Marris *et al.*, 1997; Siegrist, Keller *et al.*, 2005; Sjöberg, 2000a, 2002a). These critics turned research attention to the characteristics of the ‘risk perceiver.’ Besides the above-discussed differences between experts and laypeople, individual, social, and cultural characteristics, as well as institutional factors, became in the focus of researchers, as will be discussed in the following paragraph.

Box 1.2: Mobile Communication and the Psychometric Paradigm

Some studies using the psychometric paradigm introduce mobile communication as one technology in their research analysis set (Bronfman & Cifuentes, 2003; Siegrist, Keller *et al.*, 2005, Wiedemann & Schütz, 1996). These studies found that mobile communication is perceived as a medium dreadful and little-known hazard.

It is important to notice that base stations and cell phones exhibit different characteristics. Exposure to cell phone radiation is voluntary whereas exposure to base stations is involuntary. Hand devices are more familiar, and the benefits are more perceivable than the benefits of base stations. In addition, the public perception may vary over time. Due to changing user behavior and changing awareness of base stations, the public's perception may change. Therefore, study results must be considered with care.

4.2 Individual and Cultural Characteristics and their Influences on Risk Perception

One of the main questions in the research field of individual and cultural characteristics is: “Are there relevant personality traits that influence the perception of risk, and how are these traits distributed among social groups and cultures?” Stable personality traits that were found to correlate with risk perception include, for example, ‘sensation seeking’ (e.g., Franken *et al.*, 1992; Roberti, 2004), ‘desire for control’ and ‘ambiguity intolerance’ (Meyers *et al.*, 1997), ‘anxiety’ (e.g., Bouyer *et al.*, 2001), as well as ‘risk sensitivity’ (Sjöberg, 2000b).

But factors like personal experiences (Barnett & Breakwell, 2001) and various attitudes¹ (e.g., Ajzen, 2001; Frewer *et al.*, 2004, 1998a; Sjöberg, 2002b) were also found to affect people’s perceptions. Depending on the specific concept, trust can be seen as a trait (e.g., Rotter, 1980; Siegrist & Gutscher, 2005; Yamagishi & Yamagishi, 1994) or at least as an attitude towards people or entities. Trust has been found to influence risk perception and risk communication in various ways (e.g., Siegrist *et al.*, 2007). For example, when people lack information or knowledge in regard to a new technology they rely on their judgments of trust in the involved actors. A study by Siegrist and Cvetkovich (2000) showed that trust was more important for acceptance when respondents’ knowledge of a technology or an activity was limited.

An often-found result is that demographic characteristics like gender, age, race, nationality, and education account for risk perception or non-acceptance of a technology. For example, females were often found to perceive greater risk (e.g., Davidson & Freudenburg, 1996; Siegrist & Gutscher, 2005), whereas white males perceive lesser risk than other demographic groups (Slovic, 1999, 2000; for overviews e.g., Greenberg & Schneider, 1995; Pidgeon *et al.*, 1992, pp. 109-110; Renn & Rohrman, 2000; Renn & Zwick, 1997, pp. 44-62; Meyers *et al.*, 1997). In Box 1.3 the reader can find

1. Attitude is defined as a tendency to evaluate a particular entity (the attitude object) with a certain degree of favor or disfavor. Therefore, risk perception can be seen as a specific form of an attitude toward the technology in question (Frewer *et al.*, 2004).

results of mobile communication studies that surveyed individual characteristics.

The Cultural Theory (Douglas & Wildavsky, 1982; Dake, 1991; Rayner, 1992; Thompson *et al.*, 1990) locates the determinants of risk perception in the social-cultural context of the individual. The theory defines four distinct value orientations or worldviews (fatalists, individualists, hierarchists, and egalitarians), which react to risks in different ways. Studies using these concepts found moderate explanatory power for risk perception (e.g., Brenot *et al.*, 1998; Marris *et al.*, 1998; Sjöberg, 1997; cf. Slovic, 1999).

Finally, an integrative concept deserves mention. An approach called ‘Social Amplification of Risk (SARF)’ offers a conceptual framework for understanding how psychological, social, cultural, and political factors interact to amplify risk. It illustrates how the dynamics of a risk debate may evolve as a function of the action patterns of media and various interest groups (e.g., Kasperson *et al.*, 1988; Krinsky & Golding, 1992; Pidgeon *et al.*, 2003). For example, the framework tries to explain why society worries about particular risks (e.g., power plants) and why other risks receive comparatively little attention (e.g., highway accidents). The reasons are seen in the interactions of objective hazard characteristics (e.g., number of deaths, social consequences)

Box 1.3: Individual Perception of Mobile Communication

Various studies surveyed public risk perception and health concerns in regard to EMF emitted by mobile communication. These studies found that within the context of other environmental and health risks, EMF are rated lower than hazards such as air pollution and quality of food products (e.g., European Commission, 2007). The studies also found various differences in reference to demographic variables and country of origin (e.g., Rowley, 2005). In regard to health concerns, results of the Eurobarometer 272a (European Commission, 2007) showed, for example, that 48% of the respondents were concerned (very and fairly concerned) over the potential health risks of EMF. Respondents were more concerned about the potential health risk of base stations than cell phones. Similar results were obtained by other studies. In general, base stations tend to be perceived more negatively than cell phones and evoke more negative associations, which are related to elevated risk perception (e.g., Hutter *et al.*, 2004; Siegrist *et al.*, 2006; Siegrist, Earle *et al.*, 2005).

In the context of base station EMFs, Siegrist *et al.* (2003; cf. Poortinga & Pidgeon, 2003) showed that trust and confidence had a strong impact on the acceptance of a base station in one's vicinity. The authors presumed that people do not possess sufficient knowledge in this field and rely on social trust for risk assessments.

with a wide range of cultural, social, and psychological processes. Mobile communication studies that investigate such social interactions and their consequences are summarized in Box 1.4.

In general, it can be said that the consistency of research results in regard to individual and cultural characteristics is in some degree inhomogeneous. This may be due to the different methodologies and research strategies, the peculiarities of the objects under investigation, as well as interactions between individual factors and hazard types.

4.3 Cognitive versus Affective Processes?

The research field of risk perception focused in its first period mainly on cognitive aspects. New approaches in risk perception research put affect¹ in the center, namely the role of affective processes within the individual in judgment, decision-making and risk perception. It is important to note that affective processes are not seen as inferior or opposite to cognitive processes but rather as complementary, the two working together. These interactions are not yet fully understood (Finucane & Holup, 2006).

Affective connotation was implicit in the psychometric paradigm (the dread factor) but received more attention

Box 1.4: Social Interactions and Risk Perception

Several studies explored aspects of public controversies around mobile communication (e.g., precautionary measures, base station siting). The interactions between authorities and different interest groups have particularly attracted the attention of scientists (e.g., Lezaun & Soneryd, 2007; Petts *et al.*, 2003; Soneryd, 2007; Stilgoe, 2007). For example, Stilgoe (2007) highlighted the (co-)production of public uncertainty in the UK case. He showed how “the states of scientific uncertainty are produced along with public engagement in science” (Stilgoe, 2007, pp. 57). Furthermore, results of experimental studies by Wiedemann and Schütz (2005) suggest that precautionary measures set up by authorities might trigger health concerns, enhance risk perception, and decrease trust in public health protection (see also Wiedemann *et al.*, 2006; cf. Burgess, 2007). White *et al.*, (2007) showed that regulation preferences for cell phones are influenced by various factors, such as risk and benefit perception.

Wiedemann, Clauberg *et al.*, (2003) described a new concept for risk amplification: the ‘risk stories model.’ They showed that emotional context information (outrage /leniency) leads to very different perception of the same risk (cf. Burgess, 2002).

1. The term ‘affect’ expresses an overall degree of positivity or negativity toward the attitude object (cf. Finucane *et al.*, 2000).

with the influential work by Loewenstein *et al.* (2001) and Slovic *et al.* (2004). The so-called ‘affect heuristic’ (Slovic *et al.*, 2004) states that human beings use their positive and negative feelings in evaluating the risks and benefits of an object or hazard, as well as their knowledge and convictions. In this way affect acts like a moderator in regard to the inverse relation of risk and benefit perception (e.g., Alhakami & Slovic, 1994). For example, if a technology evokes strong negative feelings, risk perception is high and benefit perception is low. It is even possible to lower the risk perception of a technology by enhancing benefit perception (e.g., Finucane *et al.*, 2000).

Affective processes were also shown to play a part in the stigmatization of new technologies (Gregory *et al.*, 1995; Jones *et al.*, 1984; Krewski *et al.*, 1995; Peters *et al.*, 2004; Slovic *et al.*, 1991). Kasperson *et al.* (2001, pp. 19) defined stigma as follows: “a mark placed on a person, place, technology or product, associated with a particular attribute that identifies it as different and deviant, flawed or undesirable.”

4.4 The Influence of Knowledge and Beliefs on Risk Perception

As stipulated by the ‘Social Amplification of Risk,’ framework, the experts and the public may only perceive a new risk when they are informed about it. Therefore, the available information, and existing knowledge and beliefs, are relevant for risk perception. It is beyond the scope of this introduction to give an overview of the research areas of information processing, attitude change, and risk communication (see e.g., Frewer *et al.*, 1997; Johnson, 2005; Trumbo, 2002). In his reflections about the role of knowledge in lay risk perception, Johnson (1993) distinguished three different foci: factual knowledge, belief structures (also called mental models), and judgment heuristics. The following paragraph focuses only on the first two points because judgment heuristics was not a central topic in the present thesis.

4.4.1 Does Education and Information Provision Affect Risk Perception?

The idea that the public simply should be better informed or educated in order to accept a new technology was not as successful as expected. The studies conducted found heterogeneous results (Johnson, 1993). For example, studies found only moderate negative correlations between risk perception and knowledge (e.g., European Commission, 1997; Sjöberg & Drottz-Sjöberg, 1991); some even found an increased risk perception related to more knowledge (e.g., Kennedy *et al.*, 1991; MacGregor *et al.*, 1994; Morgan *et al.*, 1985). The relation between knowledge and attitudes like risk perception must not be linear. Peters (2000) reported U-shaped relations between knowledge and acceptance, and suggested several reasons for that. Increased knowledge and understanding was also shown to polarize attitudes (e.g., Frewer *et al.*, 1998b). This may depend on the prior attitudes already held by the population, as well as people's preferences for information that is consistent with already held views.

The weak and inconsistent effects of knowledge enhancement on risk perception may have three explanations. First, knowledge may not be a dominant factor for risk perception. Affective components like fear and trust might be more important (Peters, 2000). Second,

Box 1.5: Lay Knowledge about Mobile Communication

In the field of mobile communication knowledge has been assessed by using single questions (Bianco *et al.*, in press; Siegrist, Earle *et al.*, 2005), exposure ratings and familiarity with EMF key words (e.g., Büllingen & Hillebrand, 2005; Yaguchi *et al.*, 2000), or self-assessments of one's knowledge level (Ruddat *et al.*, 2005). Some qualitative studies estimate participant's knowledge by evaluating their responses to specific questions or their freely expressed statements (e.g., Drake, 2006; Law & McNeish, 2007). These studies concluded that laypeople's knowledge is deficient. It is questionable whether these studies adequately depicted laypeople's knowledge because the proposed measures did not reflect the complexity and diversity of questions related to EMF.

In regard to effects of information provision, a study by Thalmann and Wiedemann (2006) showed that emotional information polarized existing beliefs and influenced participants' risk appraisals.

Public Responses to Precautionary Information: A research group led by Barnett (Barnett *et al.*, 2007, Timotijevic & Barnett, 2006, 2007) explored public awareness and responses to governmental precautionary measures around mobile communication. Their research reports a complex picture. Most important, precautionary advices meant by the government to decrease people's health concerns may foster concerns. These results are in line with results by Wiedemann and Schütz (2005) reported above.

the methodologies used to assess the public's knowledge are not adequate. Designing a good knowledge questionnaire is difficult. The researcher needs an extensive understanding of the issue in question. In practice, social scientists are often challenged to formulate items about technical details they are not familiar with. Vice versa, well-informed engineers might struggle with constructing a good questionnaire. Without interdisciplinary cooperation, item formulation might be random (measures for mobile communication knowledge are reported in Box 1.5). In addition, respondents' time and patience is limited. Therefore, questionnaire length cannot be excessive. Hence, it is understandable that many item sets attempting to measure knowledge are rather rudimentary. The selection of knowledge items might also be biased by scientists' own interests, attitudes, cultural as well as educational backgrounds, and methodological artifacts are thereby produced (cf. Peters, 2000, pp. 273).

Third, the weak correlation between knowledge and risk perception may be due to a lack of differentiated consideration of knowledge domains beyond technical details. Researchers need to pay attention in regard to different knowledge domains relevant to lay attitudes. Wynne specified for example "the formal contents of scientific knowledge; methods and processes of science; and its forms of institutional embedding, patronage, organization and control" (Wynne, 1992, pp. 42). In particular, the target public needs to understand the risk concepts used by scientists and responsible authorities. Or vice versa, scientists need to learn how the public interprets the information they provide to them (cf. Frewer *et al.*, 2003; Keeney, 1995). For example, scientific risk concepts often include numerical representations of small probabilities. Laypeople's difficulties associated with this kind of representation are well known (Visschers *et al.*, 2007) and represent an additional challenge.

To sum up, researchers have to identify the specific knowledge units that are relevant for people's understanding of the risk. This identified knowledge structure is still insufficient. Communicators need to learn how these knowledge units can be communicated adequately to the multitudes of publics they face (Irwin & Wynne, 1996). It might also be necessary to investigate how to address the correction of misconceptions or inappropriate beliefs about related topics. To satisfy these requirements, a systematic process is needed. Morgan *et al.* (2002) proposed with the 'Mental Model Approach,' a

procedure to identify relevant knowledge elements and to develop adequate communications.¹

4.4.2 The Mental Model Approach

The authors of this approach state that people process new information within the context of their existing beliefs. In other words, the nature and extent of people's knowledge and beliefs are relevant for designing communication messages (Morgan *et al.*, 1992). Therefore, the 'Mental Model Approach' seeks to identify both accurate and inaccurate beliefs held by the public. The approach is a systematic method for identifying, presenting and evaluating factual content and is guided by the belief that "effective communication must focus on the things that people need to know but do not already" (Morgan *et al.*, 2002, pp. 19). Morgan and colleagues (2002, pp. x) stressed that the 'Mental Models Approach' is more "a field guide rather than a cookbook" and that the method must be adapted to the particularities of the topic in question. Mental model approaches were successfully applied for various risk topics such as radon (Atman *et al.*, 1994; Bostrom, Atman *et al.*, 1994) and wildland fire (Zaksek & Arvai, 2004) but is not restricted to them (cf. Morgan, 2005; V`ari, 2004). The authors propose five consecutive steps:

Step 1: Create an expert model: Based on literature reviews and interviews with a broad range of experts, an influence diagram is built that illustrates how and by which processes the nature and magnitude of the risk is determined. This network is aimed at showing the range of important factors for hazard-related decisions. This model collects all relevant informational aspects and represents a collective expert view without implying that their beliefs are superior to lay beliefs. Experts' mental models result from long hours of study and wide experience. Consequently, in reference to the work of Chi *et al.* (1981), the authors of the 'Mental Model Approach' argued that these models differ fundamentally from lay mental models. The expert influence diagram serves as a template for characterizing a layperson's mental model and provides information about the appropriateness, specificity, and

1. Please note that the term 'mental model' is used by various research communities and is therefore defined and used in different ways (cf. Fischhoff *et al.*, 1993, pp. 194-195; V`ari, 2004; Wynne, 1995). For example, Kraus *et al.* (1992) used a somewhat similar methodology to explore laypeople's 'intuitive toxicology.'

category of knowledge of laypeople's mental models. The major task of communicators, therefore, is to identify and select the relevant knowledge pieces from this broad expertise and convey them in public-centric communication tools. The following steps support communicators in accomplishing this difficult task.

Step 2: Conduct mental model interviews (laypeople interviews): Open-ended interviews are used to elicit people's beliefs about the hazard. To ensure that all relevant topics are addressed during these interviews, the influence diagram is used as a guideline. By contrasting expert and laypeople's mental models, beliefs, misconceptions, and knowledge gaps can be identified. Lay interviews also provide insights about respondents' perceptions of the social dynamics of the field. These interviews may be supplemented with additional tasks, such as questions involving pictures and diagrams, because it might be difficult to formulate structured questions about topics without provoking a certain answer (Morgan *et al.*, 1992, pp. 2053).

Step 3: Conduct structured initial interviews (survey): Based on expressed beliefs, a confirmatory questionnaire is constructed and administered to a representative group in order to estimate the prevalence of the identified beliefs. This step is aimed at determining which specific knowledge elements are lacking and which misconceptions need correction for a broad audience.

Step 4: Draft risk communication: The results of the interviews and the questionnaire are used to develop communications with regard to the decisions that people face. These communications are aimed to fill the relevant knowledge gaps and correct inaccurate beliefs.

Step 5: Evaluate communication: The developed communications are tested and refined with individuals from the target group until the communications are fully understood as intended.

4.4.3 Strength and Weakness of the Mental Model Approach

The 'Mental Model Approach' allows communicators to focus on the key aspects of a topic. In the present information age, people's attention is limited. Therefore, communication must strictly concentrate on the relevant issues

and consider the public's needs. The proposed approach incorporates expert and lay views and is, therefore, also able to pay attention to the homogenous lay public in risky matters.

The approach was said to have practical benefits only when misconceptions and knowledge gaps were involved, but it now offers orientation for affective components. Mental model approach was criticized for lack of standardization, which implies a deficiency in the validity and reliability of the results. In addition, the approach is said to show difficulties in handling expert dissent and uncertainty in regard to scientific evidence (Johnson, 2002).

The last point is of particular concern for these research projects because expert dissent and scientific uncertainty are at hand. For risk assessment of chemical risk, an understanding of exposure is essential. A study by MacGregor *et al.* (1999) showed that laypeople hold unreliable exposure concepts. The same might be true for the exposure to EMF by mobile communication. Research projects that investigated people's knowledge of power line EMF showed that respondents misjudged EMF emissions (Morgan *et al.*, 1990). Therefore, it might be a compromise to assess, besides people's understanding of the nature and magnitude of the risk, people's exposure beliefs (cf. Riley *et al.*, 2001).

5 Knowledge Gap and Research Questions

Risk perception of mobile communication has been analyzed mainly by means of quantitative surveys. Scattered qualitative studies were dedicated to various aspects, but to the best of our knowledge no studies have been conducted that explored what kind of knowledge laypeople need to understand the nature and magnitude of the uncertainty associated with EMF emitted by mobile communication. Previous studies showed deficient lay knowledge and inaccurate exposure assessments in regard to various EMF sources, but no study has explored the beliefs that led to these assessments. There is also a significant lack of understanding of how laypeople link EMF of base stations and cell phones to adverse health effects. Laypeople's beliefs about mobile communication and its influence on human health have not been satisfactory explored. The understanding of these relations may support

risk communicators in providing useful information to the interested public. Communicators must have a vital interest in delivering functional information to their public because misleading communication is known to erode trust in the responsible actors, and lost trust is difficult to rebuild (e.g., Slovic, 1993, 1999). In addition, misperceived risk may lead a society to invest resources in unfavorable ways.

The aims of the present research project are threefold: First, the potential elements or topics involved in the public perception of mobile communication will be identified. The ‘Mental Model Approach’ seems to propose a useful approach to achieve this task. Contrary to the above-mentioned critics, our intention is to identify not only factual knowledge and belief structures but also the social processes that shape perception. Second, laypeople’s knowledge and belief structures will be analyzed in depth. The resulting findings will be used to support further risk communication in regard to information provision. Third, the role of cognitive and affective components in risk perception will be explored. Table 1.2 gives an overview of the studies, their concrete research questions and the applied methodology. In addition, the Chapter titles and a brief verbal description of the research activities are provided.

Table 1.2. Dissertation overview: The studies conducted, main research questions and applied methodologies

Content of the Study and Main Research Questions	Applied Methodology
II. Mental models of experts, laypeople, and base station opponents Are there significant differences in the mental models of experts and laypeople? Do they account for risk perception? What kind of knowledge gaps and misconceptions can be identified in laypeople's mental models? How do laypeople perceive the uncertainty involved with mobile communication and how do they cope with these uncertainties?	Qualitative interviews with experts and with laypeople
III. Assessment of laypeople's knowledge and base station siting preferences What do laypeople in general know about mobile communication? What kind of knowledge gaps and misconceptions can be observed in the general population? Does knowledge differ in regard to socio-demographic groups?	Survey study: Mail questionnaire
IV. Assessment of laypeople's health concerns and health beliefs How do EMFs of mobile communication affect humans' health according to laypeople's beliefs? Are there group-specific differences in regard to risk perception and health concerns?	Survey study: Mail questionnaire
V. Influence of confidence on the processing of new information How do factors like prior beliefs, hazard source and study outcomes influence laypeople's confidence in the results of risk assessment studies?	Experiment
VI. Implicit attitudes toward technologies: The role of affect Do implicitly-measured attitudes contribute to our understanding of risk perception? Does affect influence one's risk perception?	2 survey studies: IAT and digital questionnaire

Chapter II - Risk Perception of Mobile Communication: A Mental Model Approach

An adaptation of the 'Mental Models Approach' was used to reveal laypeople's beliefs about mobile communication and to learn more about potential knowledge gaps, misconceptions, and laypeople's information requirements. Through the means of open interviews with Swiss experts, unconcerned laypeople and base station opponents, mental models were constructed and evaluated. Comparisons between the expert and the lay groups showed several qualitative differences in all identified knowledge domains. Misconceptions of exposure due to the interaction patterns of cell phones and base

stations, as well as misconceptions about regulation issues and scientific processes, were found in both lay groups. In addition, lack of trust in responsible actors and feelings of helplessness in the base station siting processes were mentioned.

Chapter III – Public’s Knowledge of Mobile Communication and its Influence on Base Station Siting Preferences

The study explored what people know about mobile communication and how this understanding influences people’s perceptions and preferences in regard to this omnipresent technology. A questionnaire, based on the mental model methodology, was designed to learn more about people’s knowledge, intuitive understanding, exposure awareness, and base station siting preferences. The mail-survey, conducted in the German-speaking part of Switzerland, showed that laypeople’s knowledge varied considerably across knowledge domains and depended on demographic characteristics. Participants had limited knowledge about interaction patterns between cell phones and base stations, and they misjudged the resulting exposure magnitudes. The observed knowledge gaps or misconceptions were related to respondents’ preferences regarding base station siting. These findings provide guidance to improved conceptualization of consumer information in regard to personal exposure awareness and, if desired, prevention.

Chapter IV - Laypeople’s Health Concerns and Health Beliefs in Regard to Risk Perception of Mobile Communication

There is an absence of convincing scientific evidence for health risks of RF exposure levels below those recommended in international guidelines. Even in the absence of scientific evidence, some citizens are worried about EMF emitted by mobile communication and its consequences for health. The study explored, by means of a mail survey, health concerns and the prevalence of health beliefs related to EMF in the general population. A random sample of the German-speaking population in Switzerland was asked to assess various health beliefs. Results suggest that health concerns are widespread but lower than health concerns relative to other hazards. About two thirds of the respondents believed that some people suffer from electromagnetic hypersensitivity (EHS). Health beliefs items were analyzed using the Mokken scale. This resulting scale was related to respondents’ health con-

cerns and showed that health beliefs differed in respect to gender, age, and self-reported EHS. Results indicate that it is important for policy makers to develop a clear understanding of the possible effects of health beliefs on health concerns and risk perception.

Chapter V - Biased Confidence in Risk Assessment Studies

The study examined factors that influence laypeople's confidence in the results of risk assessment studies. A 2 (hazard; cell phone, base station) x 2 (study outcome; no risk, risk) x 2 (health effect; well-being, cancer) x 3 (risk perception prior to the manipulation; low, medium, high) design was used. Results showed that participants had more confidence in studies with results that were in line with their prior attitudes compared with studies that were at odds with their prior attitudes. In addition, participants had more confidence in studies showing a risk compared with studies showing no risk. Results suggest that these biases may be one of the reasons why laypeople are concerned about technological risks, even when risk assessment studies indicate that there is a low probability of adverse health effects.

Chapter VI - Implicit Attitudes toward Nuclear Power and Mobile Phone Base Stations: Support for the Affect Heuristic

In the last research step, the IAT (measures automatic associations) was adapted to measure implicit attitudes toward technological hazards. In Study 1, implicit and explicit attitudes toward nuclear power were examined. Implicit measures (i.e., the IAT) revealed negative attitudes toward nuclear power that were not detected by explicit measures (i.e., a questionnaire). In Study 2, implicit attitudes toward EMF hazards were examined. Results showed that cell phone base stations and power lines were judged to be similarly risky and, further, that base stations were more closely related to risk concepts than home appliances were. No differences between experts and lay people were observed. Affect seems to have been an important factor in risk perception.

Chapter II

Risk Perception of Mobile Communication - A Mental Model Approach



Abstract

Some laypeople confronted with a new base station project fear serious health consequences from the high-frequency radiation, while experts consider exposure under the current international standards as unproblematic. These conflictive estimations may be attributed to the different mental models of laypeople and experts. Less is known about laypeople's knowledge in regard to mobile communication and their intuitive understanding of the associated health risks. An adaptation of the 'Mental Models Approach' (Morgan et al., 2002) was used to reveal laypeople's beliefs about mobile communication and to learn more about potential knowledge gaps, misconceptions and laypeople's information requirements. Through the means of open interviews with Swiss experts (N = 16), laypeople (N = 16) and base station opponents (N = 15), different mental models were constructed and evaluated. Comparisons between the expert and the lay groups showed several qualitative differences in all identified knowledge domains. Knowledge gaps in regard to changing exposure magnitudes due to the interaction patterns of cell phones and base stations as well as misconceptions about regulation issues and scientific processes were found in both lay groups. In addition, lack of trust in responsible actors and disaffection with base station location processes were mentioned. The reported qualitative insights may be useful for the improvement of further risk communication tools.

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1 Introduction

Compared with other environmental hazards, such as air pollution or ultraviolet rays, people rate mobile communication as a relatively modest health risk (e.g., European Commission, 2007; Schreier *et al.*, 2006). Risk perceptions of citizens may change, however, when they are confronted with a new base-station-siting project in their neighborhood. Numerous protests against new mobile phone base stations in Switzerland clearly illustrate people's suspiciousness regarding new radiation sources. Some people fear serious health consequences from high-frequency electromagnetic fields (EMF) and call for the banishing of base stations to locations outside their villages. At the same time, cell phones are very popular in Switzerland. Approximately eight out of ten persons over sixteen years old own a cell phone (BACOM, 2007; Bieri *et al.*, 2007). The increasing use of cell phones and the introduction of new mobile communication technologies, such as UMTS, necessitate the construction of additional base stations. More conflicts have to be expected in the near future.

Laypeople's concerns may contrast with experts' views. The scientific studies related to the radiofrequency (RF) of mobile communication provide "little support for adverse health effects ... at levels below the current international standards" (Valberg *et al.*, 2007). However, there is a lack of long-term studies. As a result, there is a slight disagreement among experts about the probability of adverse health consequences and the appropriateness of the implemented precaution measures (Hutter *et al.*, 2000; Schütz & Wiedemann, 2005). In most countries, the current radiation exposure standards are based on recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998). Switzerland applied the precautionary principle and decided to reduce exposure limits by a factor of ten for the so-called 'sensitive areas' (Del Pozo & Papameletiou, 2005). Despite these precautionary measures and the fact that people are more exposed to RF emitted by cell phones than by base stations, some citizens still seem to be more concerned about the siting of new base stations than about the radiation emitted by their cell phone (Asendorpf, 2002). Some people are willing to invest considerable effort to hinder the construction of base stations in their proximity. The question thus arises: Why are affected laypeople so concerned about base stations but not concerned about their cell phones? A lack of knowledge or a lack of understanding of how mobile communication

functions could be important factors. This possible explanation evokes another question: What kinds of knowledge do citizens need to make informed decisions related to base stations and cell phone use? Based on the literature we are aware of, it is unclear what laypeople know about base stations and cell phones and how this knowledge (or lack thereof) may influence acceptance or refusal of a base station in one's neighborhood.

1.1 Laypeople's Risk Perception of Mobile Communication

Results of studies that used the psychometric paradigm suggest that mobile phone radiation is perceived as a medium dreadful and little-known hazard (Bronfman & Cifuentes, 2003; Siegrist, Keller *et al.*, 2005). Base stations tend to be perceived more negatively than cell phones (e.g., Siegrist, Earle *et al.*, 2005; Hutter *et al.*, 2004). Results of a Swiss survey reveal that base stations evoke negative associations, which are related to elevated risk perception (Siegrist, Earle *et al.*, 2005). Results further suggest that trust in regulatory authorities is positively associated with perceived benefits and negatively associated with perceived risk. The importance of affect for risk perception was also shown in a study using the implicit association test (Siegrist *et al.*, 2006).

The authors of a review about mobile communication information campaigns and their effects (Ruddat *et al.*, 2005) maintain that the general public possesses only weak objective and subjective knowledge about mobile communication. The media was named as the main information source. Other studies asked respondents about the field strength and exposure magnitudes of different electronic devices (Yaguchi *et al.*, 2005) or about their familiarity with EMF key words (Büllingen & Hillebrand, 2005). Both studies concluded that laypeople's knowledge is deficient. Influence factors on regulatory preferences for mobile phone technologies (White *et al.*, 2007) and the effects of the use of precautionary measures on risk perception and trust were also examined. The Swiss precautionary approach may enhance risk perception because severe exposure standards can be interpreted as a signal of possible danger associated with this technology (Wiedemann *et al.*, 2006; Wiedemann & Schütz, 2005). Research done by Barnett, Timotijevic and colleagues reveals similar patterns. For persons already apprehensive, precautionary advice was seen as confirming existing concerns (Timotijevic & Barnett, 2006) or even to enhance existing concerns (Barnett *et al.*, 2007).

Public reactions to precautionary advice seem to be complex and multilayered, and they deserve further systematic research.

In summary, only a few studies have examined laypeople's perceptions of risk associated with cell phones and base stations. It is unclear how knowledge influences risk perception. The question of whether knowledge gaps facilitate public opposition to new base stations also remains open.

1.2 Improving Risk Communication: The Mental Models Approach

Morgan and colleagues (2002), in their book titled 'Risk Communication: A Mental Models Approach,' described a systematic way of identifying and evaluating the factual content of risk topics and to improve risk communication. The authors pointed out that "effective communication must focus on the things that people need to know but do not already." (Morgan *et al.*, 2002, pp. 19). Therefore, it is crucial to identify both accurate and inaccurate beliefs that are held by the target public. The proposed approach consists of five steps (Morgan *et al.*, 2002, pp. 20-21): Step 1 - Create an expert model: Based on literature reviews and interviews with a broad range of experts, an influence diagram is built that illustrates how and by which processes the nature and magnitude of the risk is determined. This model collects all relevant informational aspects and represents a collective expert view without implying that their beliefs are superior to lay beliefs. Step 2 - Conduct mental model interviews: Open-ended interviews are used to elicit people's beliefs about the hazard. To ensure that all relevant topics are addressed during these interviews, the influence diagram is used as a guideline. By contrasting experts' and laypeople's mental models, beliefs, misconceptions and knowledge gaps can be identified. Step 3 - Conduct structured initial interviews: Based on expressed beliefs, a confirmatory questionnaire is constructed and administered to a representative group in order to estimate the prevalence of these beliefs. Step 4 - Draft risk communication: The results of the interviews and the questionnaires are used to develop communications with regard to the decisions that people face. These communications aim to fill relevant knowledge gaps and correct inaccurate beliefs. Step 5 - Evaluate Communication: The developed communications are tested and refined with individuals from the target group until the communications are fully understood as intended.

The mental models approach has been adapted to examine various risk issues such as radon (Atman *et al.*, 1994; Bostrom, Atman *et al.*, 1994), climate change (Bostrom, Morgan *et al.*, 1994; Read *et al.*, 1994), chemical risks (e.g., Cox *et al.*, 2003; Niewöhner *et al.*, 2004) and wildland fire (Zaksek & Arvai, 2004). The mental models approach has also been used to analyze perception of low-frequency electric and magnetic fields (Morgan *et al.*, 1990). Results of this study suggest that respondents dramatically underestimated the dynamic range of field strengths and the rate at which fields decrease with distance from sources. Respondents could not differentiate between the field strengths associated with various appliances, and they were confused on matters related to shielding. All these issues could also be of interest regarding high-frequency electromagnetic fields.

Morgan and colleagues (2002, pp. x) stressed that the mental models approach is more “a field guide rather than a cookbook” and that the method must be adapted to the particularities of the topic in question. A major difference between the topic of mobile communication and most other risk topics addressed by the mental models approach is that there is an important lack of scientific knowledge. It is not clear whether mobile communication EMF below the international standards imply a risk or not. The World Health Organization (WHO, 2002, pp. 7) concluded in one of its publications:

Concerning radiofrequency fields (RF), the balance of evidence to date suggests that exposure to low level RF fields (such as those emitted by mobile phones and their base stations) does not cause adverse health effects. Some scientists have reported minor effects of mobile phone use, including changes in brain activity, reaction times, and sleep patterns. In so far as these effects have been confirmed, they appear to lie within the normal bounds of human variation.

Presently, research efforts are concentrated on whether long-term, low level RF exposure, even at levels too low to cause significant temperature elevation, can cause adverse health effects. Several recent epidemiological studies of mobile phone users found no convincing evidence of increased brain cancer risk. However, the technology is too recent to rule out possible long-term effects.

The absence of scientific evidence of adverse health effects of EMF exposure below the exposure standards may affect the construction of an influence diagram that aims to highlight the nature and magnitude of the risk as originally intended by Morgan and colleagues. As a compromise, we explore people’s beliefs about the magnitude of exposure to EMF associated with various sources because this parameter is measurable and probably linked to people’s perceptions of risk.

1.3 Rationale of the Present Study

To the best of our knowledge, studies have failed to examine laypeople's knowledge or mental models concerning mobile communication or its high-frequency fields. Little research has focused on laypeople's initial understanding of mobile communication and their requisites for gaining an intuitive feeling for the nature and magnitude of a risk. Therefore, the aim of this paper is to close this knowledge gap and to gain insight into laypeople's mental models of mobile communication and health risks.

Inspired by the first two steps of the mental models approach, two constitutive studies were performed: In Study 1, an expert model was developed, the aim of which was to identify all relevant knowledge aspects of the field and to build a basis for the next steps of our research. In Study 2, laypeople's beliefs and conceptions about mobile phone communication and health risks were examined by the mean of interviews. These mental models were compared with the expert model. Qualitative differences and similarities with the expert model were thereby identified. Our principal aim was to assess the accuracy of people's knowledge and unveil relevant knowledge gaps and misconceptions. By doing so, it may be possible to achieve a better understanding of laypeople's information requirements and to further improve risk communication.

2 Study 1: Construction of an Expert Model

The expert model attempts to provide a comprehensive and collective representation of all aspects that experts consider to be relevant for a conceptual understanding of mobile communication and related health issues. A graphical model, which captures all qualitative elements, was constructed and provides a kind of map of an 'objective view.'

2.1 Method

In order to construct a basic expert model, literature from relevant fields was reviewed and analyzed (e.g., Hug & Rapp, 2004; Rösli & Rapp, 2003; WHO, 2000, 2002, 2005, 2006). Technical knowledge about functional aspects of mobile phone communication as well as current scientific knowl-

edge about health risks associated with high-frequency electromagnetic fields was studied. Based on this initial model, interview guidelines were developed which covered all relevant fields. The expert model was improved and enhanced subsequent to each expert interview.

2.1.1 Participants

Relevant persons for the expert interviews were identified by an actor analysis for Switzerland based on the World Wide Web. Attention was paid to select accredited persons with different backgrounds and viewpoints on the topic. In total, 16 interviews (3 females, 13 males) were completed and evaluated. Table 2.1 shows the professional backgrounds of the interview partners.

Table 2.1. Backgrounds of interviewed experts from a Swiss expert sample

Professional Backgrounds of Interview Partners	Number of Interviews
Cell Phone Communication Provider	3
Federal Authorities	2
EMF Control Authority	1
Local Authority (Council Leader, Responsible for Siting Permissions and Public Information)	1
Research (Technical Aspects of EMFs)	2
Research (Health, Epidemiology)	2
Doctors	2
Technician in EMF Measurement Technology	2
Consumer Protection Board	1
Total	16

2.1.2 Interview Guidelines

A questionnaire with open questions was used. The interviews started off with general and nondirective questions that allowed respondents to express their beliefs. Experts were asked to create their own model and to explain it. The key question that guided this task was: *“What do laypeople have to know about the technical aspects of mobile communication in order to understand potential risk and health concerns and to make informed deci-*

sions?” In addition, factors that may influence lay people’s perception were discussed. Experts were also asked to give their own risk perception of EMF.

In a second step, our initial model was presented to the experts, and they were asked to comment on it. The first author conducted all interviews, which lasted between one and two hours. The interviews were recorded and transcribed. Based on the interviews, the initial expert model was extended with additional elements and pathways not mentioned in the literature. The final expert model is presented in the following result section.

2.2 Results

Figure 2.1 shows a simplified expert model, which depicts the main components and the interactions among them. The model is not a technical or causal flowchart. In order to provide a comprehensible representation, some minor redundancy must be accepted. The model shows, on one hand, how mobile communication works and how EMF interacts with the human body. On the other hand, it identifies relevant aspects related to risk perception and risk communication. The model has three main parts that will be explained in some detail. For reason of length and comprehensibility we chose to focus mainly on the technical aspects and to provide only a sketchy overview to the other knowledge fields.

2.2.1 Technical Aspects

The first part, named ‘Technical Aspects,’ illustrates the operating mode of cellular phone networks and identifies factors that influence exposure to EMF. Experts agreed with this part of the model. The most essential box is the one called ‘Total of Electromagnetic Radiation,’ since all other highlighted components illustrate how the character and magnitude of radiation exposure is composed. This exposure mix consists of electric as well as magnetic fields at many different frequencies. Other radiation sources and possible electromagnetic interactions also contribute to the exposure. Therefore, the ‘Total of Electromagnetic Radiation’ a person is exposed to can be described in terms of ‘exposure distribution in time,’ ‘exposure time,’ ‘exposure magnitude’ and ‘composition of the different exposure sources.’ It is a highly demanding task to measure personal exposure to all frequencies for any given 24-hour period. This causes problems for scientific studies striving to de-

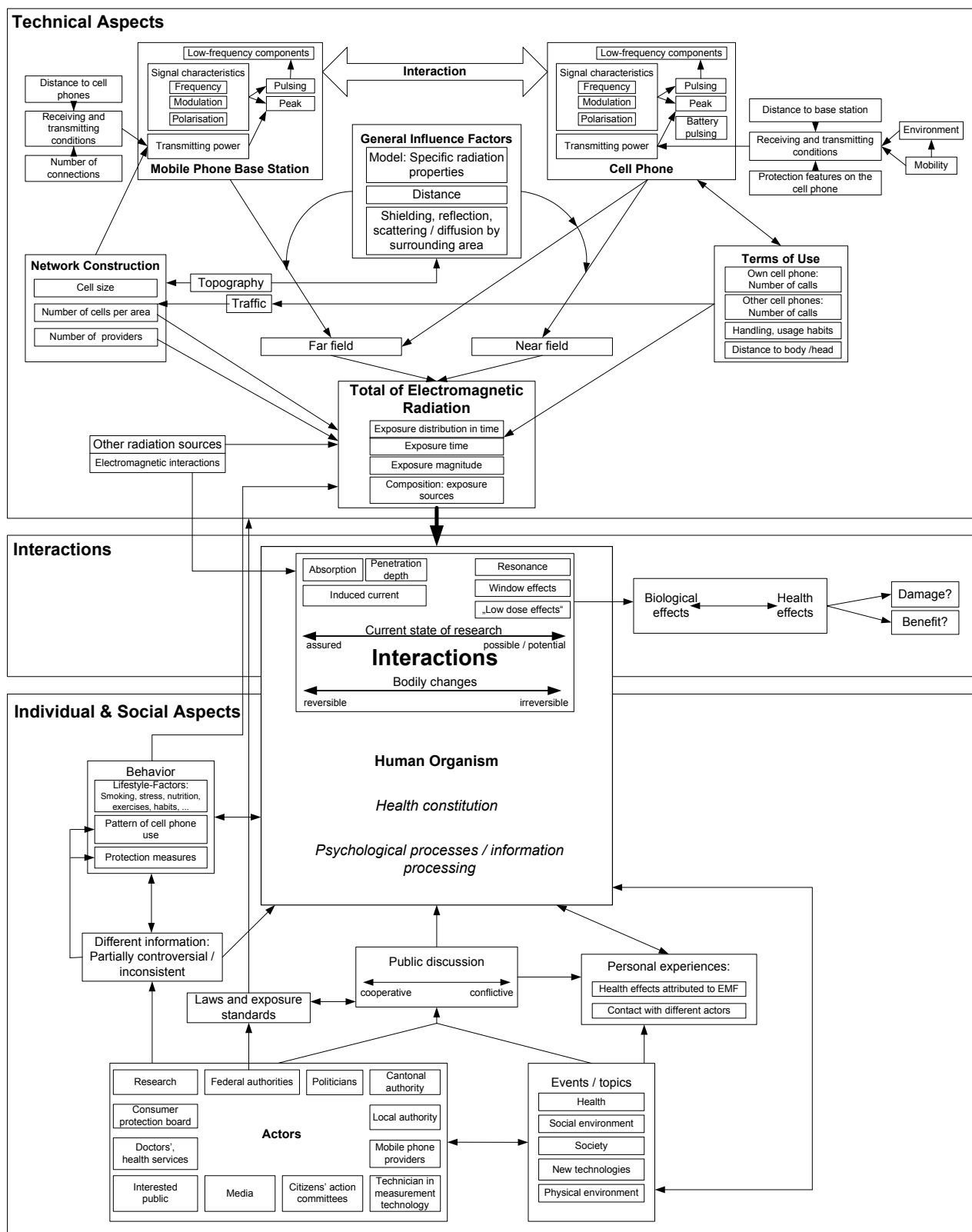


Figure 2.1. Final mental model of experts: Mobile communication

scribe causality (Ahlbom *et al.*, 2004). In regard to mobile communication, two RF sources have to be considered. Radiation of 'Mobile Phone Base Station' and that of 'Cell Phone' are each influenced by different factors. Never-

theless, both entities interact and depend on each other. Normally, citizens are exposed to the far fields of base stations. By holding a cell phone directly next to the head, people are exposed to the near field of their cell phone but also to the far fields of other cell phones. Radiation of both components can be characterized by technical parameters or ‘signal characteristics’ like frequency, modulation, polarization, and resulting pulsing and peaks. Actually, dissimilar technologies like GSM and UMTS are used in Switzerland, which differ in these described parameters. Under other ‘General Influence Factors,’ distance to the source, impacts of the surrounding area, and employed base station or cell phone model must be named. Base stations have one or more specific beam directions and specific radiation properties. Therefore, the emitted EMFs can vary enormously around the base station. Depending on the model, cell phones also emit different degrees of EMFs. These differences are labeled by the specific absorption rate (SAR), which can be taken into consideration in purchasing decisions (WHO, 2002, pp. 63). Shielding, reflection and diffusion affected by topographic factors as well as by distance have an influence on radiation required. Due to the interactions between base stations and cell phones, the amount of transmitting power necessary depends on these and other reception and transmitting conditions. For example, if the phoning person is moving, the cell phone may switch from one base station to another. Every time a cell phone and a base station must establish a new connection, they first radiate with maximal power before reducing to an optimal level (GSM). Therefore, mobility significantly affects exposure. Features such as protection covers also require cell phones to radiate more. Finally, terms of cell phone use impact ‘Total of Electromagnetic Radiation’ as well. For example, cell phone handling or usage habits (e.g., utilization of a head set, preference for SMS rather than calls, making calls only under good receiving conditions, calls on the go) significantly account for individual exposure. In regard to the radiation dose, the distance between cell phone and the body, especially the head, is crucial.

Transmitting power and radiation of base stations vary constantly. The so-called ‘broadcast channel’ (GSM) works day and night and assures connection possibilities for the phones, while all other channels work only on demand. The emitted power changes as a function of the communication load (traffic). At night, when nobody is phoning, the base station radiates notably less than during peak hours. Additionally, network construction influences transmitting power of base stations considerably. Networks with small

cell sizes (area that is operated by one base station) need weaker base stations than networks with large cell sizes. The Swiss hilly topography necessitates more base stations than in flat areas. Also, expected traffic (communication load) influences the number of base stations that are needed per area. Thus, taking the above-mentioned variables into consideration, it appears that distance from a base station alone is not an adequate indicator of radiation exposure.

2.2.2 Individual and Social Aspects

The most essential box here is the one called ‘Human Organism,’ which symbolizes an individual person. On the one hand, the individual interacts with its social environment, and on the other hand the consequences of the radiation exposure take place in the human body. For this reason, the box ‘Human Organism’ overlaps the sections ‘Individual and Social Aspects’ as well as the box ‘Interactions.’

Various factors influence the effects of EMF on human health. Experts mentioned aspects of ‘Health constitution’ like genome, circadian rhythm and self-healing processes. Behavioral aspects affect both physical and psychological health. Lifestyle factors like smoking, stress, nutrition, exercise, and other habits influence individual well-being and regeneration capacity. Patterns of cell phone use or preventive measurements against radiation influence the radiation dose as well as the perceived health concerns in regard to EMF.

Psychological processes are also considered to be relevant. Perceived risk can influence behavior or can lead to increased information search and processing. The experts perceived the available information as crucial. In the field of mobile communication and health effects, the available information is partially either controversial or inconsistent. There is even some disagreement among accredited experts about the extent and the relevance of uncertainties in the scientific knowledge related to EMF and human health (Hutter *et al.*, 2000; Schütz & Wiedemann, 2005). This results in a public discussion about electromagnetic hypersensitivity and the state of scientific knowledge as well as laws and exposure standards. The available information reflects the diversity of opinions. Furthermore, the quality of this information can vary considerably, and it is difficult for laypeople to assess it.

In sum, personal experiences (e.g., health effects attributed to EMF), the salience of the public discussion of EMF, the available information, behavioral factors shaping individual concerns, and psychological processes may affect risk perception of mobile communication.

2.2.3 Interactions

The third section, ‘Interactions,’ connects the other two parts and highlights potential health consequences due to the interactions between the ‘Human Organism’ and the ‘Total of Electromagnetic Radiation.’ As mentioned above, the interactions take place in the human body resulting in an overlap of the box ‘Human Organism’ and the section ‘Interactions.’ Despite this overlap, ‘Interactions’ is presented separately because there is a degree of difference in experts’ beliefs. Experts assess the extent and the relevance of uncertainties in the scientific knowledge related to EMF and human’s health differently. The lack of causal models explaining bodily changes and the difficulties in measuring radiation appropriately lead to incertitude, as highlighted in the box ‘Interactions.’ An assortment of interactions are known or presumed (see e.g., Hug & Rapp, 2004; Hyland, 2000; Rööslı & Rapp, 2003; Valberg *et al.*, 2007). As indicated in the box in Figure 2.1, the state of scientific knowledge (‘current state of research’) varies between ‘assured’ and ‘possible/potential.’ The effects mentioned depend on exposure. Therefore, the main question is whether there is any scientific evidence of health risks below the set exposure limits of high-frequency EMFs. The disclosed uncertainty about potential interactions is also reflected in the final expert model. The interactions between the human organism and radiation result in ‘bodily changes’ that can be either reversible or irreversible. Therefore, interactions could result in ‘biological effects’ or even ‘health effects.’ In other words, the interactions could lead to ‘damage’ or ‘benefit’ for the individual.

2.3 Discussion

At present, there is no scientific evidence of adverse health effects of EMF exposure below the exposure standards (WHO, 2002). Therefore, it was not possible to construct an influence diagram that highlights the nature and magnitude of the risk. As a compromise, we explored people’s beliefs about the composition and magnitude of their exposure to EMF because this parameter is measurable und probably linked to people’s perceptions of risk.

This was reflected in the final expert influence diagram that consisted of three parts. The ‘Technical Aspects’ part represented a traditional mental model influence diagram and highlighted all aspects that are linked to one’s exposure. In other words, this part explained how a given exposure is composed, and the box ‘Total of Electromagnetic Radiation’ replaced the normally targeted ‘risk.’ The other two parts ‘Individual & Social Aspects’ and ‘Interactions’ add new aspects to the ‘Mental Model Approach.’ Some of the boxes of these parts also explain how an individual exposure is composed (e.g., behavior), but other boxes reflect elements that contribute to the uncertainty of health effects and people’s confusion about it. For example, the model shows which elements are relevant and discussed among experts (e.g., windows effect, low dose effects) and which actors and factors are involved in the social dynamics of the problem field (e.g., public discussion, personal experiences). This expansion of the ‘Mental Model Approach’ meets half-way Wynne’s (1992, pp. 42) call for paying attention to “the formal contents of scientific knowledge; methods and processes of science; and its forms of institutional embedding, patronage, organization and control.” The supplementary aspects cannot be linked causally to individuals’ risk perception, but they can serve as a ‘road map’ for further research and may influence research designs beneficially. The qualitative approach facilitated a systemic acquisition of the problem field. Therefore, we argue that the ‘Mental Model Approach’ can be used to go beyond exploring factual knowledge.

In sum, the final expert model highlights a broad variety of knowledge elements and factors that are directly or indirectly related to the perception of mobile communication and its associated risks. The model reflects the beliefs about mobile communication and related health issues of a group of Swiss experts. The selection of interview partners was carefully planned to gather as many different viewpoints of accredited actors as possible.

This paper predominantly concentrates on the technical aspects and how the ‘Total of Electromagnetic Radiation’ is composed. Experts agree on technical as well as on social and individual aspects. Nonetheless, beliefs differ about scientific uncertainties and probabilities of possible health effects. All experts affirm that the long-term effects of low-level EMFs are unclear and that further research is still needed. Scientists continue to work on causal health-effect models, but generally accepted causal models do not currently exist. As a consequence, experts advanced different views about precaution-

ary measures and regulatory approaches. For example, they could come to no consensus about fixed radiation exposure standards (Hutter *et al.*, 2000). This uncertainty is also reflected in the final model. The consequences of the interactions between human organism and exposure remain undefined. As long as the scientific uncertainty about the relevance of exposure magnitude persist it may be appropriate to focus on laypeople's understanding of their exposure to EMF emitted by mobile communication as well as to help them to understand how they can influence their personal exposure.

Experts also reflected on public discussions. Some concluded that due to lack of evidence on health risk, everyone could advance his or her own opinions. Laypeople easily become victims of the resulting confusion and react with fear and suspiciousness. Often, experts themselves mentioned the inherent difficulties of communication caused by the complexity and the interdisciplinarity of the topic. Experts expressed doubts about whether better knowledge would change laypeople's risk perception, as they are convinced that emotions are more important to laypeople than facts.

The final expert model portrays a mental map that does more than represent that of one single expert but is rather a collection of all relevant relations and elements that might be, in the view of experts, important in the individual perception of mobile communication. It may provide a helpful overview and orientation for further studies.

3 Study 2: Lay Models on Mobile Communication

The construction of an expert model in Study 1 was an attempt to create an 'objective model.' Based on the expert model, laypeople's understanding of mobile communication and its health risks can be explored and compared with the expert view. In this way, laypeople's appropriateness, specificity, and category of knowledge can be characterized systematically (Morgan *et al.*, 1992, pp. 2050). We chose to interview two groups of participants: laypeople without strong feelings toward mobile communication and active base station opponents. This choice was based on the presumption that these two groups differ in their knowledge and attitudes towards mobile communication and may help us to identify all relevant aspects of the topic. The aims of the second study can be summarized as follows: 1. Identify all qualitative

aspects or knowledge elements that laypeople and opponents consider to be relevant for a conceptual understanding of mobile communication and related health issues. 2. Assess laypeople's knowledge range about mobile communication. 3. Identify similarities and differences between laypeople's and expert's mental models. In other words, we were interested in assessing the full range of qualitative aspects related to mobile communication.

The aim of Study 2 is neither to achieve representative statements nor to plot base station opponents against laypeople or even experts, but to create a collection of multilayered beliefs showing how individuals with various backgrounds make sense of the functionality of, and their exposure to, mobile communication. The prevalence of these beliefs needs to be assessed by a quantitative study.

3.1 Method

Open-ended interviews with interested laypeople as well as opponents of base station construction were conducted. The interviews began with general and nondirective questions that allowed respondents to express their full beliefs not influenced by the researcher's expectations. Various rating tasks complemented the interviews.

3.1.1 Questionnaire

The final expert model was used as a guideline for the laypeople's interviews. For each field of interest, different questions were posed starting with more general, nondirective questions and leading to very specific ones. Interviews began with the interviewer prompting the subject to talk freely about the issue of mobile communication (*"Tell me about mobile communication."*). Allowing respondents to say all that came to their minds gave a first impression about their knowledge. The follow-up questions were then adapted accordingly. Respondents were asked to elaborate on each of the topics they mentioned. If they failed to mention a field of interest, the interviewer introduced a related open question and continued with more detailed ones. In this manner, it could be assured that all aspects of the expert model were covered and the depth of respondent's knowledge was tapped. The order in which the questions were posed varied across respondents. Table 2.2 shows

the different topics addressed during the interviews and some examples of specific questions.

Table 2.2. Main topics addressed during interviews with examples of specific questions

Main Topics	Selection of Questions
P1 Technical Aspects	
Cell phone	Please, tell me about cell phones!
Base station	What do you think about base stations?
Network construction	Tell me about the construction of mobile phone networks!
Radiation in general	You mentioned radiation. Please tell me more about radiation!
Exposure, other sources of radiation	What do you think is the most important radiation source in your daily life?
P2 Individual and Social Aspects	
Regulation, laws, actors	Please, tell me about mobile communication in Switzerland!
Public discussion	You mentioned your read about health consequences of EMF in the newspaper. Please, tell me more about what you read!
Information seeking behavior	Have you ever searched for information about EMF?
Behavior and radiation protection activity	Please, tell me more about your cell phone use!
P3 Interactions	
Feared health consequences	Some people fear radiation of mobile communication. What do you think about that?
EMF Hypersensitivity	Some people say that they can detect electromagnetic fields. What do you think about it?
Research activities and findings	Do you know what research found out about radiation and health?

During the pre-tests it became clear that questions about radiation properties and interaction patterns of cell phones and base stations can hardly be asked without influencing the interviewee's answers. Therefore, we developed some tasks based on graphics that forced participants to elaborate their beliefs about radiation properties and interaction patterns of cell phones and base stations. The graphics used were those of both phoning and non-phoning persons in different distances to a base station or to another phoning person. Participants were asked whether radiation exposure was different

between the two scenarios and were then invited to explain their reasoning. In another task, participants were shown six maps of the same village. On each map, one, two, or more base stations were displayed as red triangles in different places as follows: one base station right in the centre, one base station on the village border, one base station far away from the village, one base station hidden in the church tower, two base stations distributed in the village, three base stations distributed in the village. Respondents were told that all base stations belonged to the same mobile communication provider and that every scenario provided full signal coverage by the mobile phone network. They were asked to rank these six possibilities according to their preferences and to explain their choice. Based on their explanations, the beliefs participants held about the radiation properties of base stations and cell phones became clear.

At the end of the interview, demographic characteristics were collected with a standardized questionnaire. All questions were carefully worded to minimize technical and academic language. The first author conducted the interviews, which took about 60 to 90 minutes each. The interviews were recorded and transcribed.

3.1.2 Participants

Two groups of participants were recruited from the German-speaking part of Switzerland. Sixteen persons (11 females, 5 males) can be described as lay-people without strong feelings towards mobile communication. Participants were recruited by flyers or by personal request. The other 15 persons (3 females, 12 males) were active base station opponents. Some of them were leaders of well-organized citizen's action committees, while others were members of small private initiatives contesting base stations in their neighborhood. Opponents' names were found in newspapers or on citizen's action committee homepages. Willingness to cooperate could be characterized as good. Table 2.3 summarizes the demographic characteristics of the interview

partners. Due to time limitations, not all opponents completed the demographic questionnaire.

Table 2.3. Demographic characteristics of the two interview groups^a

		Laypeople		Base Station Opponents		Total
		Female	Male	Female	Male	
<i>N</i>		11	5	3	12	31
EMF-Hypersensitivity		2	1	2	3	8
No Cell Phone		1	0	-	0	1
Age	<i>Mean</i>	35.18	51.17	39	49.14	43.08
	<i>SD</i>	15.84	19.24	0	12.24	16.60
	<i>Range</i>	15 - 68	24 - 70	-	35 - 66	15 - 70
	<i>Missing Data (Age)</i>	-	-	2	4	6

a. Missing values are due to exceeding of interview time.

Participants had several different levels of education and occupational backgrounds, but they were predominantly well-educated. Five opponents reported that either they or a member of their family suffered from electromagnetic hypersensitivity. In the laypeople group, three persons mentioned that they felt the influence of electromagnetic fields. At least one person did not own a cell phone.

3.2 Results

It was not possible to construct a comprehensible mental model like the influence diagram of Study 1, because some of the beliefs expressed by the different respondents were highly conflicting and sometimes even contradicting within the model of a single person. Instead, we chose to illustrate the beliefs along the paths of the expert model.

The assumption that opponents are better informed than laypeople was affirmed by the interviews. Consequently, we learned from the lay interviews about their intuitive understanding, misconceptions and knowledge gaps and from the opponents about individual, social and political processes. Therefore, we organized the results section as follows: First, we illustrate the expressed lay beliefs. Second, we highlight what we learned additionally from

the opponent group. This procedure is repeated for each of the identified knowledge domains. We were primarily interested in qualitative aspects, but we provide some quantitative data for selected questions.

3.2.1 Technical Aspects

Laypeople. All laypeople knew that mobile communication operates with radiation. In contrast, the terms radiation or high-frequency electromagnetic fields were not explained appropriately. Even less was known about technical parameters such as frequency, modulation, polarization or pulsing. Radiation was believed to decrease linearly and not with the inverse square of the distance from the source ($n = 14$). The base station contribution to overall radiation exposure was overestimated ($n = 12$) and the variation of radiation magnitude of base stations was presumed, but accurate radiation ranges were reported only twice. Concerning cell phones, all participants were aware that they are able to reduce their daily radiation dose by handling their cell phones appropriately. The measures to do so mentioned were switching off the cell phone, not wearing it on the body, and reduction of the utilization rate. Considerations about good reception and transmitting conditions were only named two times. The use of the specific absorption rate (SAR) for assistance in cell phone purchasing decisions was not applied in the past but three respondents stated that they plan to consider SAR in the future. The avoidance of the high-emitting radiation peaks caused by establishing new connections or by base station transfer was not mentioned. General factors influencing the transmitting power of base stations were predominantly unknown.

Half of the respondents ($n = 8$) were convinced that cell phones and base stations emit the same continual level of radiation. Respondents were not aware that the interaction between base stations and cell phones influences the radiation emitted of both sources ($n = 14$). Respondents ignored influence factors on radiation exposure such as distance between the base station and a particular cell phone as well as shielding effects by walls.

Similar misconceptions were also observed when respondents evaluated various scenarios for the siting of a new base station in a village. Most respondents preferred the scenario in which one base station was built far away from the village centre ($n = 13$). Respondents erroneously assumed that this

scenario resulted in a low radiation exposure for residents. Yet, cell phones emit more radiation when connecting to a base station if the distance between the cell phone and the base station increases. In other words, when cell phone users are close to a base station, their cell phone is emitting less radiation. In addition, a cell phone's proximity to the user's head accounts for significantly more of the overall exposure than does proximity to a base station (e.g., Lehmann *et al.*, 2004; Neubauer *et al.*, 2005). From a public health perspective, given that 80% of the people over 16 years old in Switzerland own cell phones, base stations should be constructed near the phoning population. Consequently, radiation exposure of cell phone users could also be reduced when several low-level base stations are built. However, most respondents ($n = 11$) rejected alternatives with more than one base station as unfavorable. When respondents were informed that cell phones emit more radiation when the distance to the base station was increased, some respondents still preferred to place base stations outside of the village, arguing that only phoning persons would be confronted with more radiation, while all others would be safe. Participants did not support the scenario of one hidden base station integrated into a church tower. Some justified their rejection by reason of moral concerns; others were opposed for reasons of transparency.

In sum, participants showed some interesting misconceptions. Distance from base stations was perceived as a protecting factor. Participants erroneously believed that more base stations would result in a higher radiation exposure of the population. Radiation power and field strength changes of the cell phones themselves were highly underestimated. Fairness was an important aspect revealed by beliefs that the person using the cell phone, and not other persons, should carry the burden of the resulting radiation.

Base station opponents. People in the opponent group had more knowledge than average laypeople. The majority were familiar with base station and cell phone properties like beam direction and specific absorption rate (SAR). In regard to personal exposure and interaction patterns between cell phones and base stations, some showed the same misconceptions as laypeople. Only few ($n = 5$) had accurate beliefs about the contributions of the different radiation sources to the overall exposure.

3.2.2 Individual and Social Aspects

Lay interviews provided a rich set of beliefs about the individual and social processes related to mobile communication. Many of the reported beliefs about social processes were linked to the specific situations and circumstances in Switzerland. Therefore, those results are not reported in detail in the present paper.

All in all, it can be said that respondents from the lay subgroup displayed a generally low level of knowledge concerning topics like laws, exposure standards and responsibilities. In regard to base station siting, they even ignored the fact that several different federal and local authorities were involved in these processes. Information about mobile communication was obtained passively, often through the media.

Laypeople, as well as opponents showed a lack of understanding of how scientific insight is gained. Qualitative aspects of studies are rarely recognized as crucial, and the outcomes of a single negative study are construed as definitive proof for the noxiousness of EMF.

Base station opponents. Base station opponents showed substantial concerns about social and political aspects of mobile communication. Base station opponents possessed a broader knowledge of laws, exposure standards, and base station siting processes than laypeople. As a consequence of their personal involvement, they actively search for information. The World Wide Web was named as the most important information source. They consulted homepages of authorities (technical information, regulation) and homepages of mobile communication critics (information about health effects). In addition, most of them are in contact with other opponent groups to share experiences.

Opponents stated different reasons for their resistance to new base stations: worries about health consequences and /or concerns about base station siting for financial, personal, or aesthetic reasons. Opponents pointed out that they were not completely against mobile communication but that they would appreciate a more precautionary approach to the use of those technologies. Opponents expressed distrust concerning the mobile phone industry and the responsible authorities. The necessity of three different networks (one for each provider) in Switzerland was questioned. Furthermore, oppo-

nents stated disaffection with base station location processes. They were concerned about base stations located close to residential areas and the exposure standards in Switzerland. Despite the precautionary radiation standards in Switzerland, opponents asked for more severe legislative measures and exposure standards.

3.2.3 Interactions

Laypeople. All but two laypeople reported a gut feeling that high-frequency fields could harm human well-being or health. Participants thought that people differ in terms of sensibility to environmental factors and that some suffer from electromagnetic hypersensitivity. Reported precautionary measures that were taken against EMF included “not wearing the cell phone on the body” and “placing the cell phone away from the bed.” Respondents were asked to identify the type of health effects and radiation sources they feared the most. Diverse effects on well-being such as headaches ($n = 10$), insomnia ($n = 7$), nervousness ($n = 5$), malaise or diffuse pains ($n = 5$) were mentioned more often than severe consequences like cancer ($n = 4$), infertility ($n = 4$), or immune-related diseases ($n = 2$). Respondents were concerned that people are exposed all hours of the day because, unlike cell phones, people cannot switch off base stations. Overall, respondents were more worried about the low, constant exposure to base stations than about the high, punctuated exposure to their own cell phone.

Participants were asked to describe how EMF affects the human body. Table 2.4 provides an overview of the effects mentioned. Radiation was believed to cause effects on cells and the nervous and immune systems or to be responsible for unspecified effects like the heating-up of tissues.

Table 2.4. Beliefs about possible effects of radiation to the human body^a

Reported Radiation Effects on Human Body	Mentioned by ...	
	Laypeople	Opponents
Nervous System		
To disrupt the nervous system, as it works also with electric impulses	4	2
To break down the blood-brain-barrier		1
To destroy the nervous system		3
To provoke or disturb brain waves		1
Cells		
To destroy cells, especially brain cells	4	2
To interfere in important metabolic cell processes		1
To hamper self-healing processes		1
To cause chemical reactions	1	
To push production of unhealthy proteins	1	
Immune System		
To cause autoimmune reaction	2	
To enfeeble immune system		1
To interfere in self-healing processes	1	3
Diverse, Unspecific Effects		
To impose pressure upon human body	1	
To charge human body	2	
To cause resonance effects		1
To affect blood circulation		2
To heat-up tissues, temperature increases of specific parts of the human body	4	2
To affect psychological well-being	2	3

a. The table summarizes only explicit stated beliefs. Multiple answers were possible.

Psychological factors were also mentioned ($n = 2$). For example, awareness of a base station and enhanced self-attention was believed to result in health problems.

Opponents. The beliefs reported by laypeople were also reported by opponents, but with higher emotional involvement and conviction. All respondents of this group were convinced that high-frequency electromagnetic fields harm human well-being or could even cause serious health consequences. Opponents expressed more elaborated beliefs than laypeople and referred to self-healing processes that take place at night. They claim that due to base station radiation, the body is not able to regenerate, and as a consequence people become ill. Some opponents were convinced that even low radiation doses could be harmful for humans' health. In other words, they believed that no safe level for EMF exists.

Several radiation characteristics were identified as dangerous. Used frequencies, specific signals of GSM or UMTS, pulsing, high radiation peaks or exposure time were named as responsible for health effects. Their lines of argumentation reflected their better knowledge about technical details of mobile communication.

3.3 Discussion

The mental model interviews were used to examine laypeople and opponents' beliefs concerning mobile communication and health risks. Study 2 aimed to identify relevant beliefs, misconceptions and knowledge gaps.

As found by other authors, laypeople possessed little knowledge about radiation and mobile communication (e.g., Ruddat *et al.*, 2005; Wiedemann *et al.*, 1994). The most important knowledge gaps found in the present study were related to the misconception of base station-cell phone interactions and the resulting radiation emitted by these cell phones and base stations. Similar to a study by Morgan *et al.* (1990), laypeople had inappropriate beliefs about the dynamic range of field strengths and the rate at which fields decrease with distance from sources. For example, participants were not aware that the distance from the base station influences the level of EMF emitted by a cell phone. In addition, inadequate knowledge concerning official procedures, regulation, and responsibilities should be mentioned.

Participants of the present study expressed similar health fears as were found in other studies (Schreier *et al.*, 2006). People were particularly worried about ambiguous symptoms like sleep disorder, headache, concentration problems, and diffuse pain, while some respondents mentioned depression or cancer. The constant 24-hour exposure to radiation emitted by base stations was perceived critically. Respondents feared that the body is under permanent stress and assumed self-healing processes are hindered from functioning. Respondents proposed increasing the distance to the radiation source in order to reduce the exposure. Similar ideas were also reported in conjunction with other radiation sources such as power transmission lines (Morgan *et al.*, 1990) or wireless home phones (Wiedemann *et al.*, 1994). Unfortunately, this strategy does not work with base stations because the cell phone radiates more when the base station is far away. In other words, locating base stations far away from residential areas may result in more exposure to EMF for cell phone users.

The most striking discrepancy between experts and the two interview groups was the degree of certainty about health effects of EMF. Experts also differed in their assessment of radiation risks, albeit slightly, but they concluded that health risks below the exposure standards were unproven. They distinguished between different effects and probabilities and referred to exigency of future research. In addition, both interview groups showed a considerable lack of knowledge in regard to processes of scientific knowledge gaining. The lines of argumentation were often guided by face validity. For example, qualitative aspects of a study were not considered and the significance of single study results was overestimated.

Respondents of the opponent group differ in some additional points from the laypeople. On average, opponents possessed more knowledge and more elaborated beliefs in every knowledge domain than laypeople. Nevertheless, opponents reported a higher degree of certainty about health effects of EMF than laypeople. Elaborated knowledge about EMF does not necessary result in better acceptance of base stations. Most opponents were not especially interested in technical details and exposure magnitude. They focused on health-relevant information like medical studies and anecdotal reports of persons that blame EMF for health problems. Based on their experiences and information from homepages of other critics, opponents steadfastly believe in the harmful effects of EMFs. Opponents did not mention the complications

of exposure measurements or other methodological weaknesses of the published studies that reported effects of EMF on human health. The validity of studies reporting risk of EMF was never questioned. Yet, opponents criticized studies that found no adverse health effects. These findings are in line with results from other studies, which showed that negative information is weighted differently from positive information (Rozin & Royzman, 2001; Siegrist & Cvetkovich, 2001; Cvetkovich *et al.*, 2002; Slovic, 1993). Negative study results fit better with opponents' prior beliefs and their own experiences. This can lead to a confirmatory bias (Poortinga & Pidgeon, 2004; White *et al.*, 2003; see also Barnett *et al.*, 2007; Timotijevic & Barnett, 2006).

In sum, knowledge discrepancies between the two lay groups and experts can be documented in different knowledge domains, but the degree to which better knowledge might influence risk perception of laypeople and opponents remains unclear. Due to the complexity of the topic and the qualitative approach it is hard to identify which knowledge elements contribute to risk perception. Factors such as perceived fairness, affect, and trust may be more important than facts (Earle *et al.*, 2007; Siegrist *et al.*, 2003). Based on the results of the present study, it can be assumed that all of these elements deserve further examination by quantitative approaches.

4 General Discussion

The first two steps of the mental models approach (Morgan *et al.*, 2002) were used to examine laypeople's understanding of mobile communication and associated health risks. The final expert model comprises technical, social, and individual aspects, and it highlights the interactions between radiation and the human organism. A special characteristic of this model is that it reflects several levels of certainty. There is no perfect consensus regarding the health-related consequences of radiation and their probabilities. As long as scientific evidence for adverse health effects under the exposure standards is not generated, it may be a useful alternative to focus on people's understanding of their personal exposure and how this exposure can be influenced.

The final expert model was used as guideline for interviews conducted with laypeople and opponents. Based on these interviews, one can conclude

that technical information about mobile communication networks seems to be important in order to understand properties and magnitude of personal exposure. Respondents tend to deduce their personal exposure from the distance to base stations and to ignore the significant contribution from their own cell phone. Unfortunately, distance to the base station alone is not an adequate indicator of radiation exposure. But this revealed misconception helps in understanding why laypeople wish to banish base stations outside of housing areas. In addition, inaccurate beliefs about exposure may result in unnecessary concerns. More knowledge in this domain cannot fully reduce the uncertainties associated with possible health effects of EMF. The certainty about harmful health effects of EMFs may also derive from misconceptions concerning scientific processes and the explanatory power of single studies. In addition, lack of knowledge in regard to regulation and site-selection processes as well as misinformation hinder an appropriate understanding of the nature and the magnitude of the potential risk. For further research, it is necessary to differentiate between the disclosed knowledge domains and to pay more attention to their significance for risk perception.

In complex situations with lack of knowledge, laypeople tend to rely on trust (Siegrist & Cvetkovich, 2000). Future studies may examine how knowledge and trust influence the risk perception of mobile communication. Trust in involved actors, as an approach to the reduction of social uncertainty as well as complexity, could be one approach (Earle & Cvetkovich, 1995).

The presented study provides qualitative insights into the mental models of experts and laypeople related to mobile communication and health. The prevalence of the revealed misconceptions and knowledge gaps remains unclear. As a follow-up to the presented two steps of the mental models approach, future research should quantitatively examine the expressed beliefs and revealed knowledge gaps and misconceptions of the general public.

Chapter III

Public's Knowledge of Mobile Communication and its Influence on Base Station Siting Preferences



Abstract

The present paper explores what people know about mobile communication and how this understanding influences people's perceptions and preferences in regard to this omnipresent technology. As shown in the past, cell phone base station siting often turns out to be a conflictive process. Citizens are not willing to tolerate base stations in their neighborhoods because they fear health consequences. They insist on siting base stations outside living areas. This solution resolves social conflict, but it may lead to more radiation for the phoning population. From a public health perspective, base stations should be located close to the people using cell phones. Knowledge and beliefs therefore play a critical role. A questionnaire, based on mental model methodology, was designed to learn more about people's knowledge, intuitive understanding, exposure awareness, and base station siting preferences. The mail-survey, conducted in the German-speaking part of Switzerland (N = 765; response rate 41%), showed that laypeople's knowledge varied considerably across knowledge domains and depended on demographic characteristics. Participants had limited knowledge about interaction patterns between cell phones and base stations, and they misjudged the resulting exposure magnitudes. The observed knowledge gaps or misconceptions were related to respondents' preferences regarding base station siting. These findings provide guidance to improved conceptualization of consumer information in regard to personal exposure awareness and, if desired, prevention.

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1 Introduction

The announcement of the installation of a new cell phone base station in a neighborhood often alarms residents. Concerned persons organize action committees and attempt to block the planned base station because they fear health consequences from the high-frequency electromagnetic fields (EMF) that would be emitted. Many people wish to locate base stations outside their living areas. At the same time, most people own cell phones and use them regularly. These conflicting reactions to the same technology are problematic because base station siting outside living areas generally leads to more exposure for cell phone users.¹ Given the fact that over 80% of the adult population in Switzerland use cell phones (BAKOM, 2007), it must not be ignored that, from a public health perspective, base stations should be located close to the people using cell phones. In the present study, we examine the question of why laypeople often favor base station locations that ultimately result in higher exposure to EMF.

Psychological research on risk perception of new technologies has focused on hazard characteristics, individual and cultural differences, as well as on affective and cognitive processes (e.g., Pidgeon *et al.*, 1992; Taylor-Gooby & Zinn, 2006). The latter includes research on the relation between knowledge and the perception of a given technology. This relation may be relevant to the perception of cell phone base stations. In fact, little is known about laypeople's beliefs and knowledge of mobile communication. The aim of the present study is to learn more about laypeople's intuitive understanding of mobile communication. The paper explores laypeople's knowledge mainly of technical aspects of mobile communication. The results may provide some guidance regarding the kind of technical information laypeople need to assess their exposure to EMF and make informed decisions related to base station siting.

1. In order to realize a connection, an increase of distance between cell phones and base stations forces both devices to radiate more. Radiation decreases with the inverse square of the distance from the source. Due to the proximity of cell phones to users' heads, cell phones account for much more of the exposure to individuals than do base stations (e.g., MMF, 2005).

1.1 Public's Perception of Mobile Communication

The fact that base stations and cell phones are perceived differently (e.g., European Commission, 2007; Hutter *et al.*, 2004) is surprising for more than one reason. First, current scientific evidence suggests that “exposure to low level RF radiofrequency fields (such as those emitted by cell phones and their base stations) does not cause adverse health effects” (WHO, 2002, pp. 7). Although possible long-term effects cannot be completely ruled out, experts have found little evidence of adverse health effects from fields below the international exposure standards (Valberg *et al.*, 2007). Second, radiation emitted by base stations is tightly regulated and controlled by authorities. Several countries even apply the precautionary principle to base stations and lower recommended international exposure standards (Del Pozo & Papa-meletiou, 2005; ICNIRP, 1998). Third, cell phones account for much more individual exposure than base stations. For example, in the case of whole body exposure, three minutes of cell phone use provide about the same amount of radiation as living one day next to a base station that exposes a person at 1 V/m (Neubauer *et al.*, 2005, pp. 36).¹ Numerous experts therefore consider cell phone radiation to be more critical for health issues than radiation emitted by base stations (e.g., IEGMP, 2000). Nevertheless, it should be noted that various sources on the World Wide Web express views that are at odds with the best available scientific evidence (e.g., <http://www.bioinitiative.org>; <http://www.mast-victims.org>). In addition, media coverage often emphasizes these contradicting views and the uncertainty in risk estimates (Koren & Klein, 1991). For laypeople, the most important source of information about health issues and risks seems to be the news media (Krewski *et al.*, 2006). Therefore, laypeople are confronted with a confusing mix of information and the difficult task of evaluating the relevance and the trustworthiness of the various sources. This may help to explain why laypeople, in various countries, are worried about EMFs emitted by base stations (Burgess, 2002).

Studies using the psychometric paradigm found that EMFs emitted by mobile communication were perceived as a medium dreadful and little-known hazard (Bronfman & Cifuentes, 2003; Siegrist, Keller *et al.*, 2005).

1. 1 V/m can be considered a high exposure value. A Swiss exposure study concluded that time averaged exposure values by GSM base stations are generally much lower than 1 V/m (Lehmann *et al.*, 2004).

Health concerns in regard to EMF emitted by mobile communication were found in several surveys. For example, the Eurobarometer 272a showed that 48% of the respondents were concerned (very and fairly concerned) over the potential health risks of EMF of mobile communication. The answer ‘not at all’ was given by only 18% of the respondents in regard to base stations and by 22% of the respondents in regard to cell phones (European Commission, 2007). Nevertheless, compared to other environmental hazards, such as air pollution or ultraviolet rays, mobile communication was rated as a relatively modest health risk (European Commission, 2007; Ruddat *et al.*, 2005; Schreier *et al.*, 2006).

It is important to note that Switzerland, like several other countries, applies a precautionary principle to EMF emissions and lowers the recommended international exposure standards for base stations (Del Pozo & Papameletiou, 2005). Several studies have found that precautionary approaches may enhance risk perception because severe exposure standards can be interpreted as a signal of possible danger associated with this technology (Barnett *et al.*, 2007; Timotijevic & Barnett, 2006; Wiedemann *et al.*, 2006; Wiedemann & Schütz, 2005).

1.2 Knowledge and Attitudes as Factors in Laypeople’s Risk Perception

Differences between experts’ and laypeople’s perception of new technologies often lead to the assumption that the public simply needs to be better informed in order to accept new technologies (Marcos & Guillem, 2004; WHO, 2002). The reality is more complicated than that (Peters, 2000). Various studies exploring the relation between knowledge and risk perception found heterogeneous results (Johnson, 1993). For example, studies found only moderate negative correlations between risk perception and knowledge (e.g., European Commission, 1997; Sjöberg & Drottz-Sjöberg, 1991), or they even found an enhanced risk perception (e.g., Kennedy *et al.*, 1991; MacGregor *et al.*, 1994; Morgan *et al.*, 1985). Peters (2000) reported U-shaped relations between knowledge and acceptance and suggested several reasons for that. Increased knowledge and understanding was also shown to polarize attitudes. This may be dependent on the prior attitudes already held by the population and people’s preferences for information that is consistent with the already held view (e.g., Frewer *et al.*, 1998). Prior attitudes may also

shape and direct one's information seeking. As shown by various studies, trust in involved actors is another important attitude in regard to risk perception (e.g., Poortinga & Pidgeon, 2003; Siegrist, Earle *et al.*, 2005). For example, Siegrist and Cvetkovich (2000) found that, when knowledge about a hazard is lacking, people rely on social trust when making judgments about risks and benefits. In the context of base station EMFs, Siegrist *et al.* (2003) showed that trust and confidence had a strong impact on the acceptance of a base station in one's proximity. The authors presumed that people possess insufficient information in this field and thus choose to rely on social trust for risk assessments. In sum, the relations between knowledge, attitudes and risk perception seem to be complex and situational.

Other difficulties are methodological in nature. Researchers need to pay attention to different knowledge domains relevant to lay attitudes. Wynne (1992, pp. 42) suggested paying attention to "the formal contents of scientific knowledge; methods and processes of science; and its forms of institutional embedding, patronage, organization and control." These domains were rarely reflected in the item selection of the studies examining the relationship between knowledge and acceptance of a technology. For practical reasons, knowledge is often assessed by single, rather general questions or self-assessments. It is questionable whether these rudimentary attempts are able to reveal the relation between knowledge and decisions related to a technology. These difficulties can also be observed in the field of mobile communication: Some qualitative studies estimate participants' knowledge by evaluating their responses to specific questions or their freely expressed statements (e.g., Drake, 2006; Law & McNeish, 2007). Survey studies often asked respondents to self-assess their level of knowledge and their information seeking behavior in regard to mobile communication (Ruddat *et al.*, 2005). A few studies used explicit questions. For example, Siegrist, Earle *et al.* (2005) utilized the following two knowledge questions: "*Does the earth have a natural electromagnetic field?*" and "*Are the regulations regarding cell phone base stations in Switzerland more severe, comparably severe, or less severe than in most EU countries?*" Another approach consists of asking respondents about the field strength and exposure magnitudes of different electronic devices or about their familiarity with EMF key words (e.g., Büllingen & Hillebrand, 2005; Yaguchi *et al.*, 2000). All these studies concluded that laypeople's knowledge is deficient, but it is questionable whether these studies adequately depicted laypeople's knowledge. The proposed measures did not

reflect the complexity and diversity of questions related to EMF. To the best of our knowledge, no study has systematically examined laypeople's knowledge of mobile communication.

In a recent study, the 'Mental Model Approach' (Morgan *et al.*, 1992, 2002) was used to examine experts' and laypeople's assessments of health risks associated with the EMFs of mobile communication (Cousin & Siegrist, 2007a). This qualitative study identified three different knowledge fields: technical aspects, individual and social aspects, and aspects concerning the interaction between EMFs and the human organism. These identified fields roughly reflect Wynne's (1992) knowledge domains. Though the insights produced by this study were broad and multi-layered, they did not allow the drawing of any conclusions regarding the prevalence in the general public of the beliefs and knowledge components that were identified.

1.3 Rationale of the Present Study

Knowledge is considered to be one of the factors that influence risk perception of EMF emitted by mobile communication (e.g., Marcos & Guillem, 2004; WHO, 2002). To the best of our knowledge, there are no studies that have examined laypeople's knowledge of mobile communication in depth. Based on the qualitative insights of a previous study (Cousin & Siegrist, 2007a), the present study examines the prevalence of knowledge in the general population by the means of a representative mail survey. The study focuses on people's understanding of their exposure to EMF emitted by cell phones and base stations. It is assumed that lack of technical knowledge leads to misconceptions of the exposure, and therefore to increased concerns in regard to base stations, and, finally, to siting decisions that increase exposure. In sum, the aim of this paper is to learn more about laypeople's understanding of mobile communication and to provide helpful suggestions for improved risk communication in regard to people's personal exposure awareness.

2 Method

2.1 Questionnaire

The present paper reports the results of only the mainly technical knowledge questions. Reports in regard to other knowledge domains are in preparation. The results of the qualitative study by Cousin & Siegrist (2007a) were used to formulate questions measuring laypeople's knowledge of mobile communication. An expert checked the technical accuracy of the items. The questionnaire covered several areas of interest. First, the 'perceived risk' of both cell phones and base stations was measured. Next, subjective knowledge and cell phone use were assessed. Twenty-six knowledge questions and two graphically-supported tasks were included in the questionnaire. The first 26 items were true / false questions with response options of 'true,' 'wrong' and 'don't know.' In addition, participants were asked to indicate their preferences about base station siting in a forced-choice task. Demographic characteristics were recorded at the end of the questionnaire. The questionnaire was carefully worded to minimize technical and academic language, and it was pre-tested in detail. In addition to the knowledge questions, participants answered questions dealing with the health risks of EMFs, attitudes and other variables. Results of these questions are not reported in the present paper.

2.2 Participants

The data for the present study come from a mail survey conducted between December 2006 and February 2007 in the German-speaking part of Switzerland. A previous study (Siegrist, Earle *et al.*, 2005) did not find relevant differences between the French and German speaking parts of the country in regard to risk perception associated with EMF. Therefore, we focus on the German speaking part. A random sample of addresses was selected from the electronic directory. The accompanying letter and the first page of the questionnaire requested that the person in the household next in line for their birthday and over 18 years of age complete the questionnaire. A reminder letter was sent out a month later. In early February, a second questionnaire was sent to households that did not respond to the letter or the reminder. In the end, 765 completed questionnaires were received and included in the data analyses (response rate of 41%).

Forty-two percent ($n = 311$) of the respondents were female, and fifty-eight percent ($n = 435$) were male. Nineteen persons did not report their gender. Reported age ranged between 19 and 105. The mean age was 51.62 ($SD = 16.37$). Twelve persons did not report their age. Twenty-seven percent of the respondents were between 19 and 39 years of age, 50% were between 40 and 64 years of age, 18% were between 65 and 79 years, and 5% were 80 years or older. Compared with the census data (BFS, 2006), males were overrepresented, while age and education level were slightly higher than the Swiss average.

Six hundred eighty-nine persons (91%) owned a cell phone. Approximately 47% of them indicated that they use it once a day or more, while 44% of the respondents use it a few times per week or month. Fifty-one respondents (7%) reported that they have protested against a base station in their vicinity. Sixty-six persons (9%) reported job-related contacts with EMF topics. A group of 116 persons said that they are affected by one or more EMF source (power lines, base stations, cell phones, wireless phones). A subgroup of 51 persons reported that they are affected by radiation emitted by mobile communication (cell phones and / or base stations).

3 Results

Mann-Whitney tests and Spearman correlations were computed because most variables did not fulfill the Gaussian distribution condition. To provide more detailed information, we chose to display means and standard deviations instead of medians.

3.1 Knowledge about Mobile Communication

Table 3.1 allows a close inspection of the questions belonging to the various knowledge domains. The question that was answered correctly by the highest percent of the respondents was related to network building depending on topography (74.1%), and the question that was answered correctly by the lowest percent of respondents was about exposure standards in Switzerland (10.6%). Respondents' correct answers for questions related to 'Cell Phones' varied between 30.3% and 66.0%. The five questions related to 'Base Stations' were answered correctly by 25.0% to 37.2% of the respondents. Ques-

tions about the 'Interaction Patterns' of cell phones and base stations were correctly answered by only 14.7% to 28.8% of the respondents. The best-answered questions can be found in the domains 'Network Building' and 'Cell Phone.' About half of the respondents knew which measures provide protection from cell phone radiation. In sum, respondents' knowledge varied considerably across the domains. In general, respondents knew most about 'Network Building' (51%), followed by 'Cell Phones' (49%) and 'Base Stations' (34%). The questions belonging to the domains 'Regulation' (22%), 'Interaction Patterns' (21%) and 'Radiation in General' (19%) were answered correctly to a lesser extent. Most wrong answers were observed for 'Regulation' (46%) followed by 'Radiation in General' (45%). Respondents often answered 'don't know' to the questions belonging to the domains 'Interaction Patterns' (53%), 'Base Stations' (41%) and 'Cell Phones' (35%).¹

For further analysis, the items of the knowledge domains with more than two questions were combined. This resulted in three summative scales: 'Knowledge about Cell Phones,' 'Knowledge about Base Stations' and 'Knowledge about Interaction Patterns.' Before the indices were computed, respondents' answers were recoded as dichotomous variables (1 = 'correct answers,' 0 = 'wrong answers' and 'don't know').

The discriminatory power of each item with regard to the subscale is provided in Table 3.1. For each scale, item analyses were done, and items with item-scale correlations less than .20 were removed. Item analysis suggested that items six and ten should be removed from the scale 'Knowledge about Cell Phones.' The final split-half reliability was $r_{tt} = .61$. The scale 'Knowledge about Base Stations' included all five original items and had a split-half reliability of $r_{tt} = .56$. To improve the reliability of the scale 'Knowledge

1. In order to formulate items about complex interrelations, some simplification must be accepted. The following items contain a simplification: Item 10 is only true for GSM systems. This is still the most widespread mobile communication technology in Switzerland. In any case, this item was not included in the final knowledge scale. Item 13 is true in most situations, but one could think of specific situations when it is wrong. Item 15 is wrong in most situations, but one could think of specific situations when it is right.

about Interaction Patterns,' item nineteen was removed. The final scale had a reliability of $r_{tt} = .68$.

Table 3.1. Overview knowledge questions regrouped in domains^a

Knowledge questions	Discriminatory power	correct answer %	wrong answer %	don't know %
Network building:				
1. The hilly terrain of Switzerland makes it necessary to have a large number of base stations. ✓	-	74.1	8.6	17.3
2. The greater the number of people who wish to use their cell phones at the same time, the greater the number of base station required. ✓	-	28.8	49.1	22.1
Cell phone:				
3. Cell phones that have a visible antenna emit more radiation than those without a visible antenna.	.441	66.0	5.6	28.4
4. The amount of radiation absorbed by your head when making a call on your cell phone can be reduced by using a hands-free kit (headset). ✓	.336	63.6	11.5	24.9
5. Special protective covers for cell phones can give users effective protection from radiation when making calls.	.358	58.4	11.0	30.6
6. If you find that your ear gets warm during a lengthy call on your cell phone, this is mainly due to the radiation given off by the handset.	.142	52.2	22.5	25.3
7. The level of radiation given off by a cell phone can be reduced by fitting the handset with special pieces of metal that redirect the radiation.	.389	50.0	7.7	42.3
8. It is possible to buy cell phones that give off less radiation than others. ✓	.304	43.4	25.1	31.4
9. When I make a call on my cell phone, the level of radiation I am exposed to is much higher from my handset than from the nearest base station. ✓	.361	42.7	16.0	41.3
10. A cell phone handset radiates more strongly while establishing a connection than it does during the call itself. ✓	.167	34.5	20.5	45.0
11. When I use my cell phone to send pictures or video clips, the handset emits more radiation than when I am simply making a call.	.264	30.3	21.6	48.1
Base station:				
12. Service providers have to keep increasing the power of their base stations to keep pace with the ever-increasing range of functions offered by cell phone handsets.	.282	37.2	30.1	32.7
13. I am exposed to much more radiation from the base station of a cordless landline phone than I am from the nearest cell phone base station. ✓	.276	36.4	20.6	43.0
14. The level of exposure to the radiation given off by a base station is greatest right at the foot of the mast.	.307	36.2	15.9	47.9

Table 3.1. Overview knowledge questions regrouped in domains^a

15. The radiation given off by base stations make up a large proportion of the total electromagnetic pollution we are exposed to.	.211	34.1	31.2	34.7
16. Cell phone base stations communicate with each other via satellite.	.334	25.0	30.1	44.9
Interaction patterns:				
17. The greater the number of people actually making calls with their cell phones at the same time, the greater the level of radiation given off by the base station. ✓	.332	28.8	49.1	22.1
18. The further away I am from the nearest base station, the more radiation my cell phone has to emit to allow me to make a call. ✓	.512	22.7	49.4	27.9
19. Generally speaking, a cell phone network consisting of many low-powered base stations results in lower levels of exposure to radiation than one that uses a few high-powered ones. ✓	.256	22.4	20.7	56.9
20. A base station gives off the same level of radiation throughout the whole day.	.371	21.2	51.3	27.4
21. If there is a good signal, I am exposed to less radiation from my cell phone than I am if the signal is weak. ✓	.524	20.4	51.5	28.2
22. The closer the base station is to the person making a call on his or her cell phone, the lower the level of radiation it the base station is required to emit. ✓	.456	14.7	55.8	29.5
Regulation:				
23. Current legislation requires that base stations should be erected in residential and industrial areas as far as possible. ✓	-	31.8	11.6	56.5
24. The maximum permissible radiation levels for base stations are more strictly regulated in Switzerland than in most other European countries. ✓	-	10.6	40.3	49.1
Radiation in general:				
25. The higher the frequency of any radiation, the more dangerous it is.	-	13.4	41.5	45.2
26. You are better protected from the electro-magnetic radiation given off by electric currents, because these flow along insulated wires, whereas cell phone radiation passes through the air.	-	25.3	47.5	27.2

a. $N = 752-760$. Numbering of questions does not correspond with the order in the questionnaire. The checks indicate, whether the statement is true.

In addition to the written knowledge questions, respondents were asked to complete two knowledge tasks using pictograms. The following instructions were given to participants: *“In each of the following questions, you are asked to decide how the level of radiation exposure experienced in the first situation (A) changes in the second situation (B). Please indicate with a cross which of the four statements you consider to be correct. In comparison with phoning person A, and taking into account the total radiation exposure from*

both cell phone and base station, phoning person B experiences....” The participants could choose between the options ‘no radiation,’ ‘less radiation,’ ‘the same amount of radiation,’ and ‘more radiation.’ Figure 3.1 depicts the pictograms used.

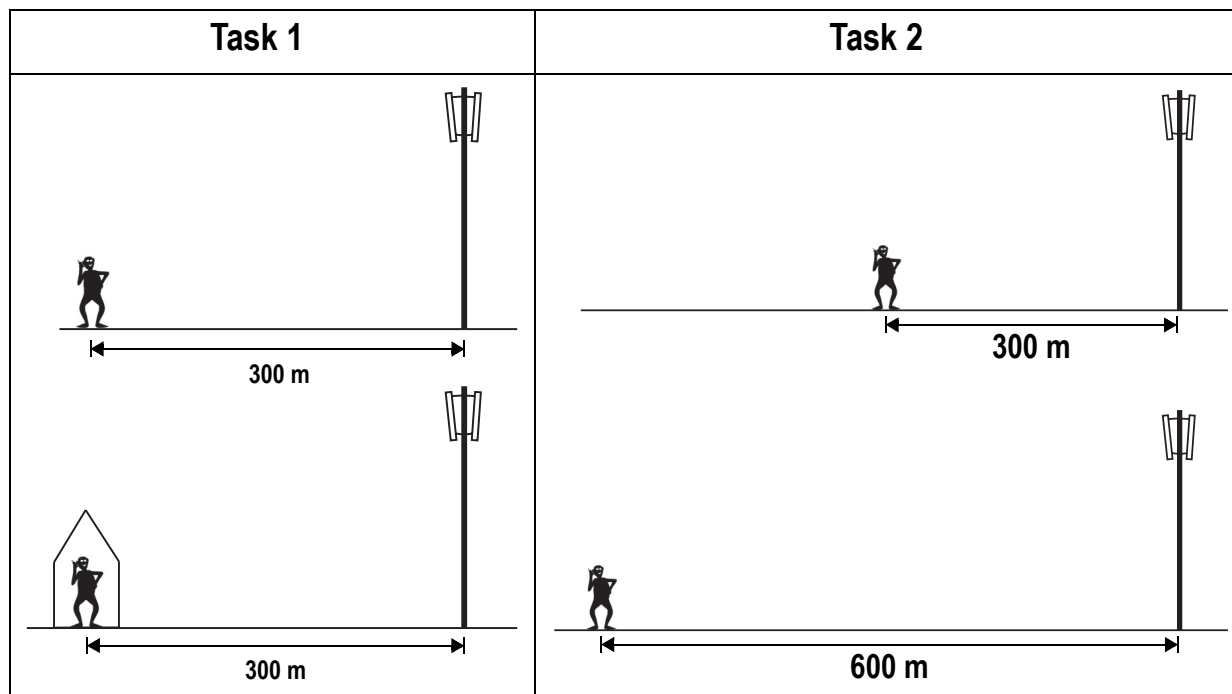


Figure 3.1. Scenarios used in the two pictogram-supported tasks

The correct answer in both situations was ‘more radiation.’ This is because the cell phone is held directly on the head and consequently accounts for more individual exposure than the base station. In the second situation of Task 1, the cell phone and the base station have to pass through the wall. Therefore, both radiate more. In the second situation of Task 2, the cell phone and the base station have to bridge a longer distance and consequently emit more radiation. Task 1 was answered correctly by 12% ($n = 88$) of the respondents. Thirty-nine percent ($n = 289$) of the respondents said that person B in Task 1 experiences ‘less radiation,’ and 47% ($n = 348$) indicated that person B experiences the ‘same amount of radiation.’ Only two percent ($n = 18$) responded that person B experiences ‘no radiation.’ In Task 2, 11% of the respondents ($n = 79$) answered correctly. About 55% ($n = 407$) of the respondents said that person B experiences ‘less radiation,’ and 31% ($n = 231$) answered that person B is exposed to the ‘same amount of radiation.’ Only three percent ($n = 25$) of the participants indicated that person B experiences ‘no radiation.’

3.2 Socio-Demographic Impact on Knowledge

We examined which socio-demographic and behavioral variables influenced respondents' knowledge. Results are shown in Table 3.2. Mann-Whitney tests indicated that males, respondents between 18-50 years, respondents with a high education level, and respondents with a professional EMF background knew significantly more than females, respondents older than 50 years, respondents with a low education level, and respondents without EMF background. In addition, both respondents not suffering from self-reported electrosensitivity and those who were daily cell phone users showed significantly more knowledge about 'Cell Phones' and 'Base Stations' compared with respondents suffering from electrosensitivity and those who were not daily cell phone users. The questionnaire included one item inquiring about respondents' willingness to protest against new base stations in their neighborhoods. Persons who did protest against base stations in the past didn't show significantly greater knowledge than persons who did not. Overall, results indicated that socio-demographic variables explained knowledge related to cell phones and base stations better than knowledge about interaction patterns.

Table 3.2. Mann-Whitney tests in regard to socio-demographic and behavioral characteristics and the knowledge scales^a

	N	Knowledge Scales								
		Cell Phone			Base Station			Interaction Patterns		
		M	z	Sig.	M	z	Sig.	M	z	Sig.
Gender										
female	311	3.02	-5.97	.000	1.39	-4.80	.000	.86	-3.25	.001
male	435	3.87			1.88			1.23		
Age										
low (18-50)	374	3.79	-3.60	.000	1.81	-2.67	.007	1.20	-2.25	.024
high (51-105)	379	3.27			1.55			.95		
Education level										
low	184	2.93	-5.14	.000	1.16	-6.54	.000	1.02	-.048	.962
high	527	3.79			1.88			1.08		
Professional background in regard to EMF										
yes	66	4.38	-3.91	.000	2.20	-3.02	.003	1.68	-3.93	.000
no	692	3.42			1.62			1.01		
Electrosensibility										
yes	116	3.19	-2.06	.039	1.41	-2.20	.028	1.17	-1.40	.162
no	649	3.56			1.72			1.05		
Cell phone using										
daily	354	3.76	-4.26	.000	1.76	-2.66	.008	1.13	-1.14	.256
weekly or monthly	217	3.02			1.47			.96		
Had protested against base station										
yes	51	3.73	-.714	.475	1.92	-1.10	.272	1.27	-.772	.440
no	707	3.52			1.67			1.06		

a. High values indicate high knowledge.

3.3 Information Search and Subjective Knowledge about Mobile Communication

Subjective knowledge about mobile communication was measured on a 6-point-scale with the endpoints 1 (= not informed at all) and 6 (= very well informed). Respondents reported having more knowledge about risks of mobile communication ($M = 3.42$, $SD = 1.31$) than technical aspects ($M = 3.03$, $SD = 1.32$) and legal aspects ($M = 2.27$, $SD = 1.24$). Table 3.3 shows that self-reported knowledge about technical aspects correlated with measured knowledge about 'Cell Phones,' 'Base Stations,' and 'Interaction Patterns.' Perceived risk of cell phones and base stations correlated weakly with the knowledge scales, and the signs of the correlations were not consistent.

Table 3.3. Rank correlations (ρ_r) between self-reported knowledge, knowledge, and risk perception^a

	Cell phones	Base stations	Interaction patterns	Perceived risk cell phones	Perceived risk base stations
Self-reported knowledge about risks	.34**	.26**	.13**	.10**	.11**
Self-reported knowledge technical aspects	.34**	.29**	.14**	-.03	-.03
Self-reported knowledge about legal aspects	.15**	.13**	.08*	-.07	-.08*
Perceived risk cell phones	.02	-.03	.09*	-	-
Perceived risk base stations	-.03	.11**	-.10**	-	-

a. **Correlation is significant at the .01 level (2-tailed), *Correlation is significant at the .05 level (2-tailed), $n = 751-758$

Only 26% of the respondents ($n = 196$) reported having actively searched for information about mobile communication. As reported in Table 3.4, Mann-Whitney tests showed that informed respondents scored significantly higher on all knowledge scales.

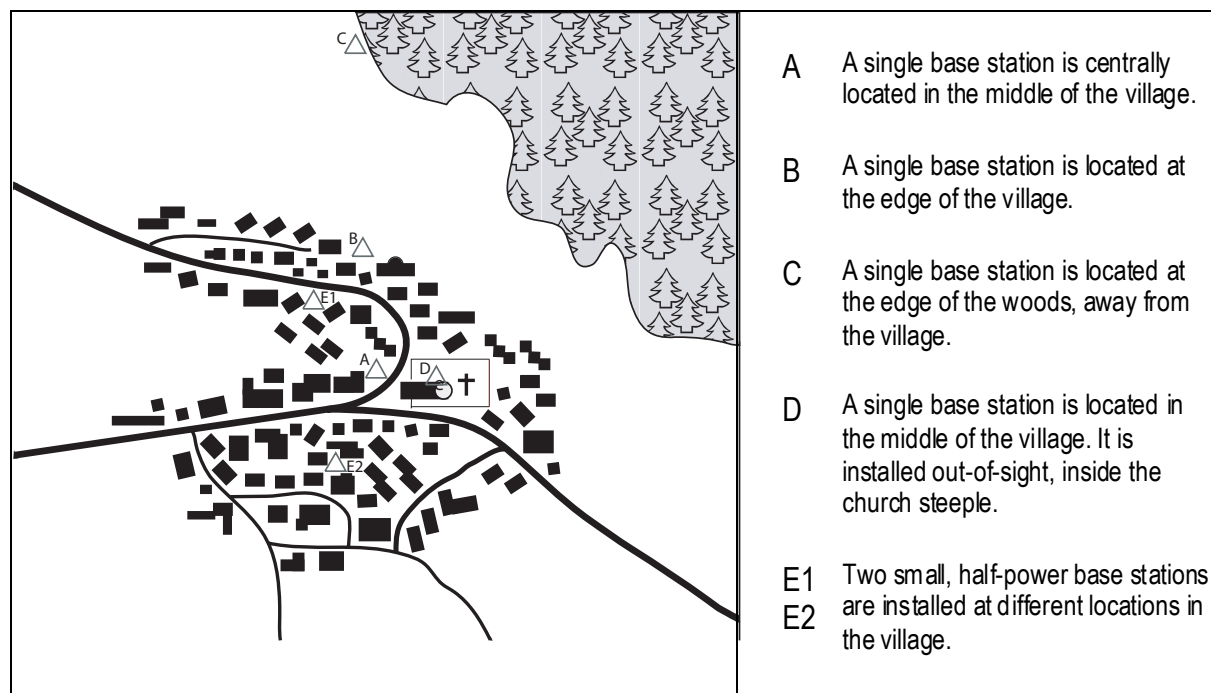
Table 3.4. Mann-Whitney tests in regard to self-reported information search, measured knowledge, and risk perceptions

	Self-reported information search about mobile communication		z	Sig.
	Yes (n = 156)	No (n = 562)		
	M (SD)	M (SD)		
Knowledge scale cell phones	4.18 (1.75)	3.30 (1.93)	-5.54	.000
Knowledge scale base stations	2.06 (1.41)	1.55 (1.33)	-4.36	.000
Knowledge scale interaction patterns	1.25 (1.45)	1.01 (1.32)	-2.07	.038

3.4 Exploratory Base Station Siting Task

Participants were asked to indicate their preferences concerning base station siting in a forced-choice task. Five different scenarios, presented as map segments, were used. In Figure 3.2, the five scenarios and their verbal descriptions are combined into one figure. The following instructions were provided to participants: *“In each of the following questions, you will see two different diagrams, each showing the layout of the same village. There are various ways in which the entire village can be provided with full signal coverage by the cell phone network. In each case, please decide which variant you would choose from the point of view of the village as a whole. The position of the base station is represented by a red triangle. Below each diagram there is also a written description of the situation. All of the base stations belong to the same service provider.”* Respondents were asked to compare all possible pairs of scenarios and, for each pair, to indicate their preferred option. Cell phone use accounts for more individual exposure than base stations do. To minimize emitted radiation by cell phones, as well as overall exposure, it is advisable to site base stations as close as possible to the phoning population. Therefore, distant base stations (edge of the village, edge of the woods) are less favorable than near ones. The scenario with two half-powered base sta-

tions would probably result in the lowest radiation for the phoning population.



This figure shows all five base station siting possibilities simultaneously. The original scenarios displayed only one possibility in each figure. To symbolize the base stations red triangles were used.
Original figure size: 7.5 cm x 6.5 cm

Figure 3.2. Scenarios and verbal descriptions of used figures in the base station siting tasks

Respondents' preferences were evaluated by counting the number of times each option was selected within and across all pairs. Table 3.5 shows the revealed preferences and should be read as follows. The numbers indicate the number of people who preferred the horizontally-written scenario compared with the vertically-depicted scenario. For example, 196 people preferred the scenario 'one base station in the center' to the scenario 'one base station on the edge of the village.' Within-pair preferences were added, and their sum is indicated in the last column.

Table 3.5. Evaluation of pro voices in regard to siting preferences^a

	1.	2.	3.	4.	5.	Total
1. One base station, center	X	196	124	170	302	792
2. One base station, edge of village	508	X	123	309	378	1318
3. One base station, edge of the woods	610	629	X	531	570	2340
4. One base station hidden in church steeple	532	391	200	X	392	1515
5. Two half-power base stations	398	326	165	311	X	1200

a. The numbers indicate the number of people who preferred the horizontally-written scenario compared with the vertically-depicted scenario. For example, 196 people preferred the scenario 'one base station in the center' to the scenario 'one base station on the edge of the village.' Missing values: $n = 13$ to 65

Overall results showed that the scenario with one base station away from the village at the edge of the woods was highly preferred. This siting possibility received the most preferred choices ($n = 2340$). Respondents indicated that the scenario with one base station installed out of sight in the church steeple was their second-placed choice ($n = 1515$), followed by one base station at the edge of the village ($n = 1318$), two half-power base stations ($n = 1200$) and one base station in the middle of the village ($n = 792$). From an exposure point of view, the alternative with one base station in the center is more or less equivalent to the hidden alternative in the steeple of the church. The comparison between these two possibilities indicates that visibility was an important factor for respondents. In each of the pairings, the hidden scenario received more preferred choices than the center scenario. In addition, when paired together the hidden scenario (chosen 532 times) was preferred to the center scenario (chosen 170 times).

We also examined the relationship between base station siting preferences and knowledge. A summative index for base station siting preferences was computed. The ten forced-choice tasks were handled like knowledge questions. The task of comparing the two similar scenarios in the center of the village was not included in the scale. Respondents therefore could

achieve a maximum score of nine points. Scenarios resulting in less radiation for the phoning public were rated as correct answers and added to a summative scale called 'base stations siting preferences' (split-half reliability $r_{tt} = .77$). This scale was significantly correlated with the knowledge domain 'cell phones' ($\rho_I = .22$; $p < .01$), 'base stations' ($\rho_I = .23$; $p < .01$) and 'interaction patterns' ($\rho_I = .10$; $p < .01$).

4 Discussion

People's differing concerns in regard to cell phones and base stations could be due to laypeople's lack of knowledge, especially in regard to the exposure magnitude emitted by these devices. However, this presumption has never been examined systematically. Neither laypeople's intuitive understanding of mobile communication nor the necessary underlying knowledge structures have been studied in depth. The present paper examined the relevance of technical knowledge elements for people's exposure judgments. Knowledge assessment was improved by employing a broad set of knowledge questions derived from a mental model approach (Morgan *et al.*, 2002). In addition, the relations between knowledge and base station siting preferences were explored.

The results suggest that lack of knowledge and understanding, especially about the interaction patterns between cell phones and base stations, is associated with unfavorable base station siting preferences, which would cause more exposure for the phoning population. Even though there is little evidence of adverse health effects from fields below the international exposure standards, it makes sense to reduce radiation exposure if it can be achieved without additional costs. People should be informed that their cell phone is an antenna too, and that their cell phone has the same functionalities as a base station. This would help them to understand the somewhat paradoxical fact that a base station in one's backyard would reduce cell phone user's daily exposure. Furthermore, enhancement of technical knowledge could help people to adopt, if desired, effective strategies to reduce their daily exposure by rethinking their cell phone handling.

Lack of knowledge in the domain 'Knowledge about Interaction Patterns' was also confirmed by a task using pictograms. The pictogram scenarios re-

vealed that respondents were not aware of the interdependency of cell phones and base stations and the resulting radiation exposure. This knowledge is crucial to estimating possible health risks caused by radiation. Response patterns suggest that, in laypeople's mental models, base stations account for significantly more individual exposure than cell phones.

In addition to the interaction patterns of cell phones and base stations, the regulatory measures adopted by authorities have considerable effect on the public's exposure. The results of the present study indicated that respondents were poorly informed about legal aspects and exposure standards. Knowledge in this domain could also help citizens to develop accurate exposure and risk estimates for different electrical devices. Furthermore, knowledge and understanding of the carefully designed legal process with regard to base station siting could enhance the trustworthiness of authorities.

As mentioned above, the lack of knowledge about 'Interaction Patterns' deserves special attention because this knowledge is needed to understand the rationality behind network building strategies. The findings of the base-station-siting task also supported the proposition that laypeople are neither aware of the interdependency of cell phones and base stations nor of the resulting radiation exposure. People strongly preferred base station siting far away from the village. Perhaps people wish to increase the distance in order to reduce the exposure because they draw incorrect analogies to radiation sources like radio broadcasters and power transmission lines (e.g., Morgan *et al.*, 1990). Unfortunately, this strategy does not work with base stations because cell phones and base stations are not unconnected entities. They radiate more when the distance increases. Specific information about these interdependencies and the resulting exposure would likely help to facilitate acceptance of base station siting within living areas. This assumption was supported by results showing that, compared with participants with less knowledge, those with a higher level of knowledge more often chose base station locations that minimized radiation for the phoning population.

The influence on siting preferences of such factors as perceived fairness and the visibility of base stations cannot be fully understood based on the present study. Qualitative interviews with base station opponents (Cousin & Siegrist, 2007a) suggested that the timing of information provision matters a lot. Limited information sharing by authorities and mobile communication

providers arouses distrust and hampers communication. Further investigations are needed to clarify the influence of these factors.

In previous research, knowledge was shown to have only limited influence on attitudes (Johnson, 1993; Peters, 2000). The correlations found in the present study between technical knowledge, base station siting preferences, and risk perception are consistent with these results. Only few respondents showed a good knowledge level. Therefore, it is an open question how the correlation would be changed when more knowledgeable respondents were included in the sample. However, other factors are also relevant. For example, Slovic *et al.* (2004) emphasized the interplay of affect and risk perception (cf. Siegrist *et al.*, 2006; Thalmann & Wiedemann, 2006). Also, trust in the actors involved has been shown to have an impact on risk perception (e.g., Poortinga & Pidgeon, 2003; Siegrist, Earle *et al.*, 2005). For example, Siegrist and Cvetkovich (2000) found that, when knowledge about a hazard is lacking, people rely on social trust when making judgments about risks and benefits. In the context of base station EMFs, Siegrist *et al.* (2003) showed that trust and confidence had a strong impact on the acceptance of a base station in one's proximity. The authors presumed that people do not possess sufficient information in this field and thus choose to rely on social trust for risk assessments. Another challenge consists in the circumstance that people trust more in information that reflects their existing beliefs (Plous, 1991; Siegrist & Cousin, 2008; White *et al.*, 2003). Therefore, it can be expected that changing existing mental models or beliefs may be quite difficult and may be moderated by one's trust in the information source.

Some limitations must be addressed. Even though the questionnaire was sent to a random sample, males, high-educated citizens, and people concerned about EMF were overrepresented (cf. Schreier *et al.*, 2006). In addition, since not all persons completed the questionnaire, the sample may be affected by a self-selection bias. It is likely that people with a special affinity to the topic were more motivated to return the questionnaire. This may have affected the pattern of relationships found in the study. It can also be assumed that the respondents to this survey knew more about mobile communication than average Swiss citizens. In addition, it must be pointed out that risk perception of mobile communication varies across countries and time. As mentioned in the introduction, Switzerland applies the precautionary principle, which was shown to enhance risk perception (e.g., Barnett *et al.*,

2007; Wiedemann *et al.*, 2006). Potential health effects of man-made EMF have been a scientific topic since the late 1800s (WHO, 2002, pp. 1-9) but have received particular attention during the last 30 years. The roll out of new mobile communication technologies (e.g., UMTS) or media coverage may temporarily trigger people's concerns. Therefore, the present study is a snap shot in time, and the level of risk perception found is not necessarily representative for other countries.

The reported reliability estimates for the knowledge subscales were a little low, and this could be a source of error variance. The subscales need further exploration. On the other hand, we computed Mann-Whitney tests and Spearman correlations. This conservative approach may have led to an underestimation of the 'true' effects.

The present study mainly explores technical knowledge about mobile communication. In real-life situations, base station siting is embedded in political and social processes (cf. Burgess, 2004; Lezaun & Soneryd, 2007). The qualitative preparatory study revealed that these aspects, and particularly the understanding of procedures as well as trust in the actors involved, are extremely important. On one side, the findings presented here represent only parts of one knowledge domain proposed by Wynne (1992, pp. 42) and have to put back in the context of decision making in real-life situations (cf. SturGIS & Allum, 2004). Aspects like public's understanding of scientific uncertainty need careful attention (Johnson, 2003; Johnson & Slovic, 1998). For example, precautionary measures may, through social amplification processes, increase rather than decrease public concerns in regard to mobile communication (cf. Barnett *et al.*, 2007; Burgess, 2007; Timotijevic & Barnett, 2006; Stilgoe, 2007; Wiedemann & Schütz, 2005; Wiedemann *et al.*, 2006). However, technical aspects should not be ignored just because they are perceived as too technical or too complicated for a lay public. The technical aspects may help consumers to achieve an understanding of the amount of radiation emitted by various devices and to adopt effective precautionary measures. As a result, health concerns or exaggerated fears could be put into perspective, and technically preferable base station siting may become easier. But the uncertainty about possible long-term effects of EMFs under the exposure standards cannot be resolved either by technical knowledge enhancement or by improvement of scientific literacy. The handling of

scientific uncertainty in society should be part of public debates and democratic processes.

Only about one quarter of the participants indicated that they had actively searched for information about mobile communication. This suggests either that the topic was not highly relevant for most respondents or that available information sources were unclear. Results of the Eurobarometer 272a (European Commission, 2007; cf. Rowley, 2005) showed that citizens would like more information about the topic of mobile communication. Therefore, it seems that adequate information provision is still an open task with plenty of room for improvement. Based on the present results, we suggest that future risk communication should pay more attention to informing citizens about interaction patterns and comparison of exposure magnitudes, and it should respect the needs of different recipient groups (Irwin & Wynne, 1996). In addition, regulatory topics and the rationality behind base station siting should be explicated adequately.

Chapter IV

Laypeople's Health Concerns and Health Beliefs in Regard to Risk Perception of Mobile Communication



Abstract

The consensus scientific view is that there is an absence of convincing scientific evidence for health risks of exposures to EMF at levels below those recommended in international guidelines. Nevertheless, some citizens are worried about EMF emitted by mobile communication and its consequences for health. The present study explored, by means of a mail survey, health concerns and the prevalence of health beliefs related to EMF in the general population. A random sample (N = 765, response rate 41%) of the German-speaking population in Switzerland was asked to assess various health beliefs. Results suggest that health concerns are widespread but lower than health concerns in regard to other hazards. About two thirds of the respondents believed that some people suffer from electromagnetic hypersensitivity (EHS). Health beliefs items were analyzed using the Mokken scale. This scale was related to respondents' health concerns and showed that health beliefs differed in regard to socio-demographic variables. For example, analyses showed that females, younger respondents, respondents who believed that some people are affected by EHS endorsed significantly more health beliefs than males, older respondents and non-EHS respondents. Results indicate that it is important for policy makers to develop a clear understanding of the possible effects of health beliefs on health concerns and risk perception. These findings may provide guidance for the further development of information materials and strategies.

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1 Introduction

In Western societies, a multitude of technical devices simplify our daily lives at home and at work. As a consequence, individual exposure to all kinds of electromagnetic fields (EMF) has increased considerably (WHO, 2002, pp. 1; Würtenberger & Behrendt, 2004). Some people are worried about this development and take precautionary measures to avoid electromagnetic fields. These kind of health concerns are also observed in the case of mobile communication. In particular, the siting of new cell phone base stations in housing areas is alarming to some residents (Asendorpf, 2002).

The increased exposure to EMF is also of concern to public health scientists. A large number of studies have investigated the health consequences of EMF emitted by various sources (e.g., Ahlbom *et al.*, 2004; IEGMP, 2000; SCENIHR, 2007; WHO, 2007a). In regard to radiofrequency (RF; 100 kHz - 300 GHz) emitted by mobile communication, current scientific evidence indicates that there is “little support for adverse health effects arising from RF exposure at levels below current international standards” (Valberg *et al.*, 2007, pp. 416). However, possible long-term effects cannot be ruled out because the technology is too young (SCENIHR, 2007, pp. 4; WHO, 2002, pp. 7).

On the World Wide Web, one can find contrary evaluations. Various websites warn of adverse health consequences and quote numerous studies that purportedly prove the harmfulness of EMF emitted by mobile communication. Interested and concerned citizens, searching for factual information, are confronted with contradictory claims. The impact of this mix of information on people’s beliefs remains unclear.

In summary, the opinions of responsible authorities, scientists and base station opponents on possible adverse health effects of EMF are well documented on the World Wide Web, but it remains unclear which health beliefs are held by the general population. Several studies have assessed laypeople’s global risk perception or health concerns in regard to mobile communication (e.g., Schreier *et al.*, 2006; European Commission, 2007). Little attention, however, has been paid to laypeople’s specific health beliefs. The present study examined the kind of interactions laypeople expressed between EMF

and human health, with the goal of better understanding how health concerns and health beliefs are related.

1.1 Possible Health Effects of EMF Emitted by Mobile Communication

According to the World Health Organization (WHO, 2002, pp. 1, 9), potential health effects of man-made EMF have been a scientific topic since the late 1800s, but have received particular attention during the last 30 years. It is important to differentiate between biological effects and health effects. The former can be described as measurable responses of an organism or a cell to a stimulus or to a change in the environment. These effects are not necessarily harmful and can be compensated for by the body. For example, heart rate increases after drinking coffee or body temperature changes during a sauna stay. Health effects result from a biological effect that causes detectable impairment in health or well-being (WHO, 2002, pp. 4). In the case of mobile communication, minor effects of cell phone use have been reported. It was observed that changes in brain activity, reaction times and sleep patterns occurred, but these changes appear to lie within the normal bounds of human variation (WHO, 2002, pp. 7; cf. Hyland, 2000). In addition, biophysical mechanisms (e.g., tissue heating) that can lead to health effects as a consequence of exposure to sufficiently strong fields were identified (SCENIHR, 2007, pp. 11). To protect citizens and to avoid such unintended health effects, evidence-based exposure limits were established (ICNIRP, 1998). There is, however, a debate among scientists over whether long-term, low-level exposure below the exposure limits can cause adverse health effects or influence people's well-being and whether the implemented precaution measures are appropriate (e.g., WHO, 2002, pp. 7; Schütz & Wiedemann, 2005).

The uncertainty in this domain is taken seriously by responsible authorities. Therefore, WHO and various countries are engaged in wide-ranging research activities (e.g., SNSF, 2007; WHO, 2006, 2007b). Several countries even apply a precautionary principle and lower the recommended international exposure standards for base stations (Del Pozo & Papameletiou, 2005).

1.2 Laypeople's Health Concerns about Mobile Communication

In general, mobile phone radiation is perceived as a moderately dreadful and little known hazard (Bronfman & Cifuentes, 2003; Siegrist, Keller *et al.*, 2005). Within the context of other environmental and health risks, EMFs are rated lower than hazards such as air pollution and quality of food products (e.g., European Commission, 2007). Several national and international studies have explored laypeople's health concerns. Results of the Eurobarometer 272a¹ (European Commission, 2007) showed that 48% of the respondents were concerned (very and fairly concerned) over the potential health risks of EMF. Respondents were more concerned about the potential health risk of cell phone base stations than cell phones. Similar results were obtained by other studies. In general, base stations tend to be perceived more negatively than cell phones and evoke more negative associations, which are related to elevated risk perception (e.g., Hutter *et al.*, 2004; Siegrist *et al.*, 2006; Siegrist, Earle *et al.*, 2005).

The influence of trust in authorities and the effect of precautionary approaches were also investigated. For example, a study by Wiedemann *et al.* (2006, see also Wiedemann & Schütz, 2005) indicated that a precautionary approach might enhance risk perception since severe exposure standards can be interpreted as a signal of possible danger. Trust in authorities was shown to be important in risk regulation and for acceptance of base stations in one's vicinity (Poortinga & Pidgeon, 2003; Siegrist *et al.*, 2003).

Little attention has been paid to knowledge-related topics and concrete health beliefs. The few studies addressing mobile communication knowledge concluded that laypeople's knowledge is deficient (e.g., Büllingen & Hillebrand, 2005; Ruddat *et al.*, 2005; Siegrist, Earle *et al.*, 2005). Health beliefs were explored indirectly in qualitative studies (e.g., Drake, 2006; Wiedemann *et al.*, 1994), but these studies disclosed neither the prevalence of the found beliefs in the general population nor the impact of health beliefs on

1. The Public Opinion Analysis sector of the European Commission (http://ec.europa.eu/public_opinion/index_en.htm) has been monitoring since 1973 the evolution of public opinion in the member states, thus helping the preparation of texts, decision-making and the evaluation of undertaken work. Their surveys and studies address major topics concerning European citizenship: enlargement, social situation, health, culture, information technology, environment, etc. In 2007 an Eurobarometer Special Surveys about "Electromagnetic Fields" was accomplished.

risk perception or health concerns. However, a study by Lee *et al.* (2005), which explored the role of beliefs in health risk perception for various hazards, demonstrated the explanatory power of health beliefs for risk perception. It seems promising, therefore, to explore these interrelations in the field of mobile communication as well.

1.3 Rationale of the Present Study

To the best of our knowledge, there are no studies that have looked at laypeople's health beliefs about mobile communication in any detail. The present study examines the prevalence of such beliefs in the general population. The aim of this paper is to learn more about laypeople's health beliefs and their relations to health concerns and risk perception of mobile communication. Knowledge about laypeople's health beliefs is important for improving risk communication.

2 Methodology

The present study was part of a multi-stage research project based on an adaptation of the 'Mental Model Approach' by Morgan *et al.* (2002). The aim of the project was to learn more about laypeople's intuitive understanding of mobile communication and its influence on risk perception. The first step consisted of qualitative interviews with various experts, laypeople and active base stations opponents (Cousin & Siegrist, 2007a). The expert interviews resulted in an expert model that comprises all aspects considered to be relevant for the understanding of mobile communication risk. Based on this model, interviews with laypeople and base station opponents were conducted. These interviews generated a large number of beliefs about mobile communication. In the second step, which we present in this paper, we tried to quantify the prevalence of these beliefs and misconceptions in the general population.

2.1 Questionnaire

The questionnaire covered several areas of interest. First, health concerns for cell phones, base stations and other environmental hazards were measured.

Second, various beliefs about the effects of EMF were assessed. Twenty-three statements were formulated. These items were based on the results of a qualitative study of laypeople's mental models of mobile communication (Cousin & Siegrist, 2007a) and represented an assortment of commonly expressed health beliefs. To assess 'non-scientific beliefs,' respondents were also asked to rate beliefs about alternative healing practices and related concepts. These topics often emerged during the qualitative interviews. Demographic characteristics were recorded at the end of the questionnaire. The questionnaire was carefully worded to minimize technical and academic language, and it was pre-tested in detail. In addition to the various health related items, participants answered questions dealing with knowledge about mobile communication, attitudes and other variables. Results of the knowledge questions were described in another paper (Cousin & Siegrist, 2007b).

2.2 Special Statistical Evaluation

The set of twenty-three health statements (health beliefs) was analyzed utilizing Mokken scale analysis, which can be described as "a combination of a measurement model and a procedure that is commonly used to assess people's abilities or attitudes. It analyzes each respondent's pattern of responses to a set of questions, or items, that are designed to be indicators of a single latent variable, i.e., the ability or attitude under study" (van Schuur, 2003, pp. 139). The Mokken scale is a stochastic elaboration of Guttman's scale analysis, to evaluate the scalability of items (Mokken & Lewis, 1982). In a perfect Guttman scale, answering an item positively means that, the respondent will answer all less difficult items positively too. This constraint is often too stringent for psychological scales. In contrast, the Mokken scale is not deterministic. Respondents answering an item positively will have a significantly greater probability than zero of answering a less difficult item in a positive way as well. More precisely, the probability of a positive response on an item is assumed to be a monotonely non-decreasing function (called Item Characteristic Curve, ICC) of the attribute measured (Sijtsma *et al.*, 1990). The ICCs of the items of a scale are expected not to intersect with other ICCs. This is referred as the criterion of double monotony, which assures that the order of item difficulties remains invariant over the value of latent trait under study. In sum, Mokken scales are composed of items with different difficulties or different proportions of positive responses (see for details e.g., Mok-

ken & Lewis, 1982; van Schuur, 2003). For data analysis, we used the statistic program MSPWIN 5.0 (Molenaar & Sijtsma, 2000).

2.3 Participants

Data collection took place between December 2006 and February 2007. A random sample of addresses was selected from the electronic directory of the German-speaking part of Switzerland. A previous study (Siegrist, Earle *et al.*, 2005) did not find relevant differences between the French and German speaking parts of the country in regard to risk perception associated with EMF. Therefore, we focus on the German speaking part. The accompanying letter and the first page of the questionnaire requested that the person in the household over 18 years of age and next in line for their birthday complete the questionnaire. A reminder letter was sent out a month later. In early February, a second questionnaire was sent to households that did not respond to the letter or the reminder.

Seven hundred and sixty-five persons returned valid questionnaires (response rate 41%). Fifty-eight percent ($n = 435$) of the respondents were male, and forty-two percent ($n = 311$) were female. Nineteen persons did not report their gender. The mean age was 51.62 ($SD = 16.37$). Twelve persons did not report their age. A comparison with census data (BFS, 2007) showed that the sample was slightly older and better educated than the Swiss average. In addition, males were overrepresented.

Several questions addressed the topic of electromagnetic hypersensitivity. Leitgeb and Schröttner (2003, pp. 387) distinguished between “electromagnetic sensibility, the ability to perceive electric and electromagnetic exposure, and electromagnetic hypersensitivity (EHS), developing health symptoms due to exposure to environmental electromagnetic fields.” In the questionnaire, we asked respondents about the second construct. A group of 116 persons said that they are affected by one or more EMF sources. A subgroup of 51 persons reported that they are affected by radiation emitted by mobile communication (cell phones $n = 36$ and / or base stations $n = 25$). Respondents who reported suffering EHS were asked whether they took one or more of the following actions: Fifty-two persons (33% of the respondents affected by EHS) stated that they took measures to protect themselves from EMF, twenty-five persons went to a doctor (16%) and thirty persons (20%)

found help through alternative medicine. Fifty-five persons (35%) who reported EHS took other active measures against the disturbances caused by EMF. About one third of the respondents (29%, $n = 218$) reported that they personally knew individuals who suffer from EHS.

3 Results

Mann-Whitney tests, Wilcoxon tests, and Spearman correlations were computed because most variables did not fulfill the Gaussian distribution condition. To provide more detailed information, we have chosen to display means and standard deviations in addition to medians.

3.1 Respondents' Health Concerns

To compare the health concerns of our subsample with those found in other studies, health concerns were assessed in regard to 'mobile communication,' 'cell phone usage,' 'usage of wireless phones,' 'power transmission lines,' 'air pollution,' and 'UV radiation.' These items were rated on a seven-point scale anchored by 1 (= no concerns at all) and 7 (= high concerns). Compared with environmental hazards such as air pollution ($M = 5.46$; $SD = 1.52$) and ultraviolet rays ($M = 5.24$; $SD = 1.51$), base stations ($M = 3.85$; $SD = 1.67$) and cell phones ($M = 3.76$; $SD = 1.65$) evoked less health concerns. Participants were comparably concerned by EMF emitted by power transmission lines ($M = 3.84$; $SD = 1.75$). A Wilcoxon test for repeated measurements showed that base stations evoked significantly more concerns than cell phones ($z = -2.51$, $p = .012$; $n = 752$).

Health concerns related to mobile communication technology were assessed using the question: "*Which device worries you most? (Please, indicate / cross only one answer).*" The respondents chose the following alternatives: cell phones 7% ($n = 52$); base stations 14% ($n = 106$), both cell phone and base station 52% ($n = 391$). About 27% of the respondents ($n = 202$) indicated that they are not worried at all.

3.2 Health Beliefs and Non-Scientific Beliefs

Respondents were asked to assess various health statements. The task was introduced as follows: *“In the following section, we would like to know what you think about possible health issues associated with mobile phone radiation. Please indicate which statements you agree with.”* Respondents were asked to indicate the statements with which they ‘agree,’ ‘do not agree,’ or whether they ‘don’t know.’ Figure 4.1 and Figure 4.2 provide an overview of the twenty-three statements. To facilitate orientation, the items are sorted in regard to the percentage of affirmative responses. Figure 4.2 shows the statements that were later summarized to a scale (see below), while Figure 4.1 shows the remaining items. Please note that which of the answers to the items are correct remains an open question. Some scientists would probably agree on the statements 1, 3, 14, and 17, but based on current scientific evidence all other statements cannot be answered definitively.

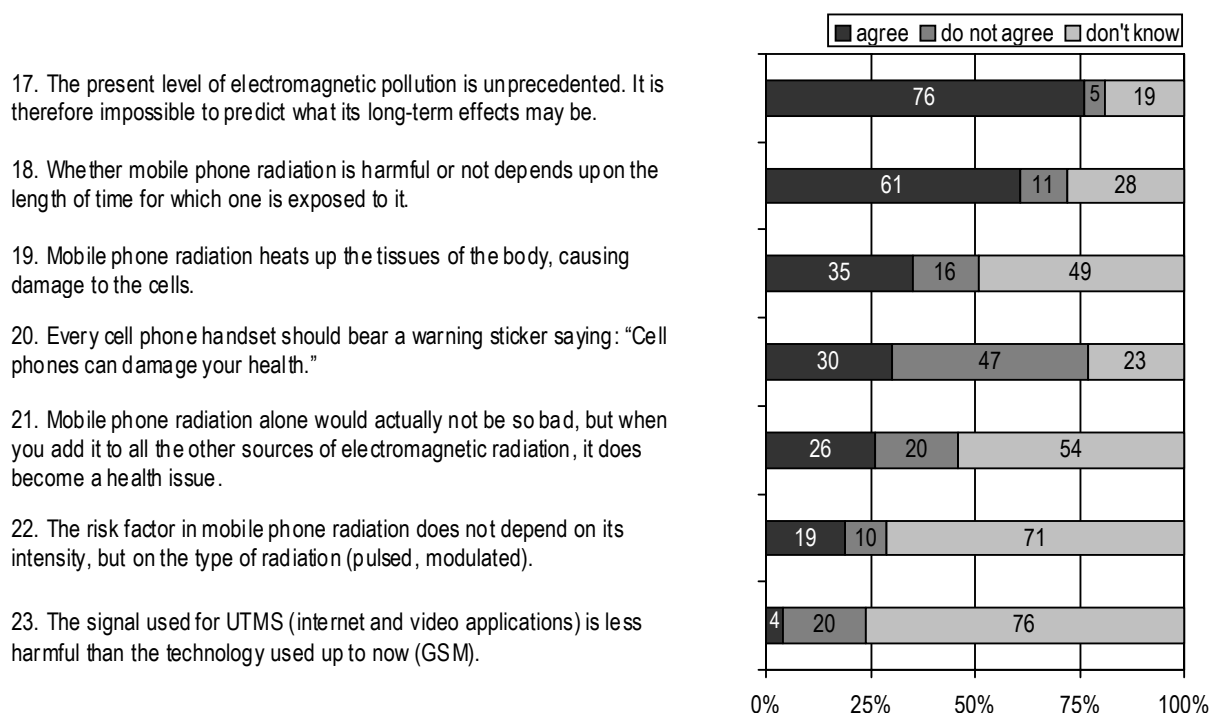


Figure 4.1. Health beliefs about EMF emitted by mobile communication: Items not included in the Mokken scale

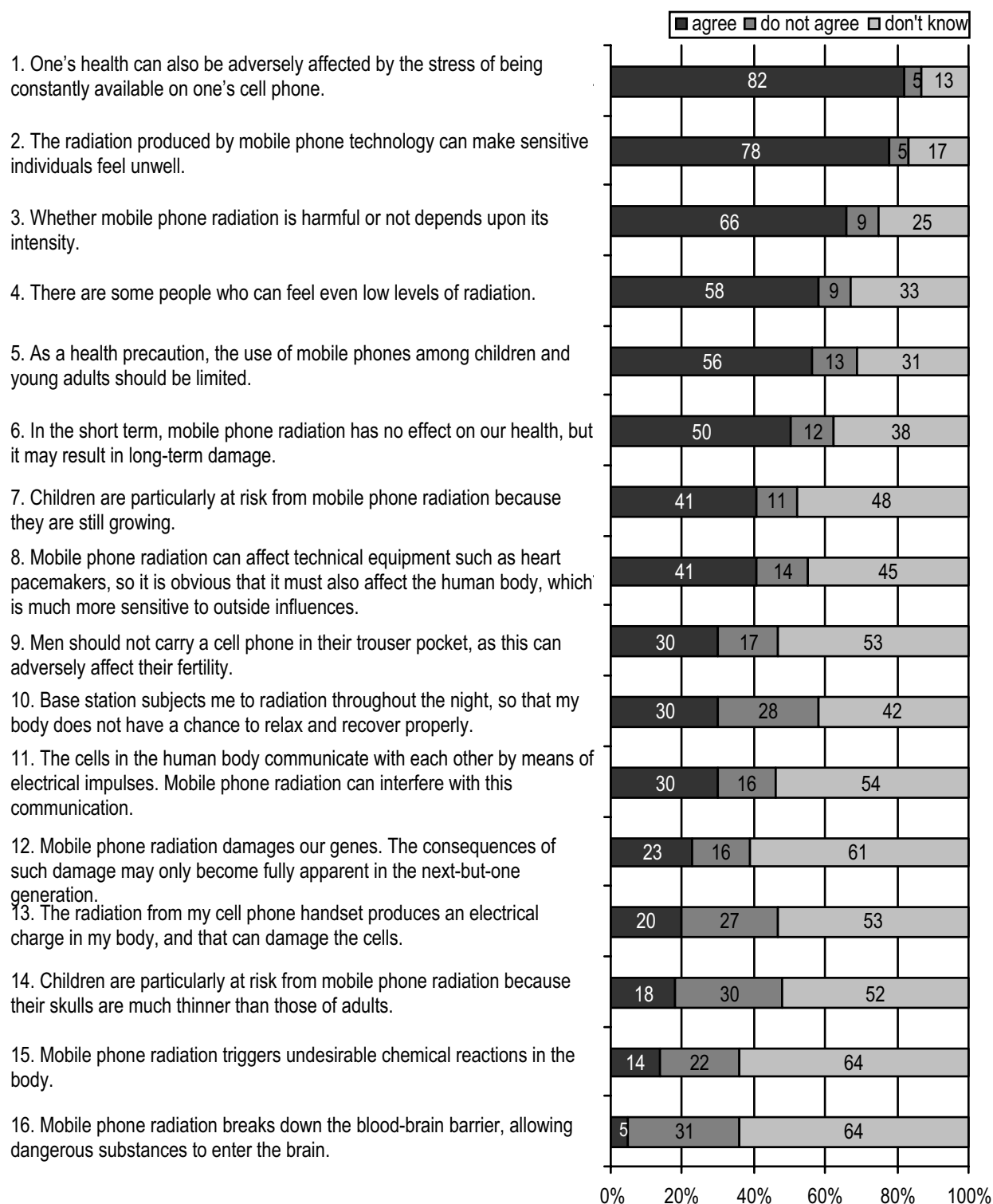


Figure 4.2. Health beliefs about EMF emitted by mobile communication:
Items included in the Mokken scale

At first view, the answer patterns vary considerably. The percentage of persons who believe that the statements are 'correct' or 'not correct' ranged

between 24% and 85%. Between 13% and 76% of the respondents indicated that they do not know the answer. Respondents agreed most with the statement about adverse health effects due to constant availability on one's cell phone (82%, $n = 616$). Items 2 and item 6, which refer to EHS, were supported by more than half of the respondents (78%, $n = 594$; respectively 59%, $n = 444$).

In a next step, we analyzed whether the health beliefs can be combined in a one-dimensional scale utilizing Mokken scale analysis. Before the scale analysis was computed, respondents' answers were recoded as dichotomous variables (1 = 'agree,' 0 = 'do not agree' and 'don't know'). We chose this coding because we were interested in constructing a scale that measures participants' mobile communication health beliefs. The final scale was composed of sixteen items and reached a reliability of $\rho = .85$. The homogeneity of an item set is tested by the Loevinger's H coefficient. To put it simply, this coefficient considers the number of model violations in a Guttman scale. A perfect scale would reach $H = 1$. In other words, the larger the H the more confidence can be held in the ordering of subjects along the latent scale (Molenaar & Sijtsma, 2000, pp. 12). A rule of thumb suggests that strong scales have an $H \geq 0.50$, H of moderate scales lies between 0.50 to 0.40, and weak scales have an H between 0.40 and 0.30 (Mokken & Lewis, 1982, pp. 422). In addition, each item requires a coefficient of homogeneity $H_i > 0.30$.

The Loevinger's H coefficient of the final item set was 0.40, which can be described as a moderate scale. The scalability values (H_i) of the single items were acceptable and ranged between 0.33 and 0.54 (see Table 4.1). Inspection of the indexes that checked the criterion of double monotony did not reveal severe violation, and visual inspection showed a satisfactory distribution of the total score across respondents (cf. Gillespie *et al.*, 1987; Molenaar & Sijtsma, 2000, pp. 47-50).

Table 4.1. Final Mokken scale with the difficulty (p) and the scalability coefficients of the items (H_i)^a

Items	p -value	H_i
1. Stress of being constantly available on one's cell phone	0.81	0.54
2. Sensitive individuals feel unwell	0.78	0.51
3. Harmfulness depends upon intensity	0.65	0.37
4. People can feel even low levels of radiation	0.58	0.39
5. Use of mobile phones among children should be limited	0.55	0.43
6. No short term but long-term damage	0.49	0.38
7. Children are particularly at risk because they are still growing	0.41	0.45
8. Sensitive human body	0.40	0.39
9. Adversely affect men's fertility	0.30	0.35
10. Body does not have a chance to relax and recover properly	0.29	0.39
11. Interfere with electrical impulses of the cells in my body	0.29	0.34
12. Damages our genes	0.22	0.41
13. Produces an electrical charge in my body, damage the cells	0.20	0.35
14. Children are particularly at risk, their skulls are thinner	0.17	0.33
15. Undesirable chemical reactions in the body	0.14	0.40
16. Breaks down the blood-brain barrier	0.05	0.54

a. $N = 765$; $H = .40$; $\rho = 0.84$

Finally, a summative index was computed and labeled as 'Health Belief Scale.' High values on this scale correspond to a strong belief in adverse health effects of mobile communication. Respondents' total scores ranged between and zero and sixteen scale points. Descriptive statistics showed a mean of $M = 6.32$ and a standard deviation of $SD = 3.68$.

Respondents were also asked to assess the following four statements about alternative healing procedures and related concepts: 1. *Mental healing and the laying-on of hands are more effective than scientists believe.* 2. *Water veins negatively influence sleep quality.* 3. *Homeopathy can be an effective method to treat health problems.* 4. *I trust alternative healing procedures.* These items were rated on a six-point scale anchored by 1 (= I do not agree at all) and 6 (= I fully agree). The items were summarized to the scale 'Non-Scientific Beliefs' (Cronbachs Alpha $\alpha = .79$).

Spearman rank correlations revealed that ‘Health Beliefs’ were significant predictors of health concerns in regard to base stations $\rho_I = .42$ ($p < .01$) and health concerns in regard to cell phones $\rho_I = .42$ ($p < .01$). ‘Non-Scientific Beliefs’ were significantly related to health concerns in regard to base stations $\rho_I = .31$ ($p < .01$) and health concerns in regard to cell phones $\rho_I = .27$ ($p < .01$). Finally, the scales ‘Health Beliefs’ and ‘Non-Scientific Beliefs’ were significantly correlated $\rho_I = .36$ ($p < .01$).

3.3 Health Beliefs and their Relation to Socio-Demographic Variables

In a further step, we analyzed whether socio-demographic groups differ in regard to their ‘Health Beliefs’ and their ‘Non-Scientific Beliefs.’ Table 4.2 shows the results of the Mann-Whitney tests.

The Mann-Whitney tests showed that females, younger respondents, respondents affected by EHS and respondents who know persons affected by EHS endorsed significantly more health beliefs than males, older respondents, non-EHS respondents and respondents who did not know persons affected by EHS. Educational and professional backgrounds did not affect health beliefs.

In regard to ‘Non-Scientific Beliefs,’ the Mann-Whitney tests revealed that females, respondents affected by EHS and respondents who know persons affected by EHS had significantly stronger beliefs than males, non-EHS respondents and respondents who did not know persons affected by EHS.

Table 4.2. Belief scales: Mann-Whitney tests in regard to socio-demographic characteristics^a

	Scale 'Health Beliefs'					Scale 'Non-Scientific Beliefs'				
	<i>n</i>	<i>M</i>	<i>Mdn</i>	<i>z</i>	<i>Sig.</i>	<i>n</i>	<i>M</i>	<i>Mdn</i>	<i>z</i>	<i>Sig.</i>
Gender										
female	311	7.04	7.0	-4.39	.000	308	4.27	4.50	-4.90	.000
male	435	5.83	6.0			427	3.83	4.00		
Age										
low (18-50)	374	6.70	7.0	-2.52	.012	370	4.00	4.25	-.54	.592
high (over 50)	379	6.06	6.0			372	4.03	4.25		
Education level										
low	184	6.00	6.0	-1.46	.144	180	3.99	4.25	-.12	.910
high	572	6.42	6.0			520	4.00	4.24		
Electromagnetic hypersensitivity										
yes	116	8.06	8.0	-5.44	.000	115	4.43	4.75	-3.93	.000
no	649	6.00	6.0			635	3.94	4.25		
Do you know persons, which suffer under EHS?										
yes	218	8.02	8.00	-7.94	.000	216	4.45	4.75	-6.09	.000
no	536	5.68	6.00			526	3.84	4.00		
Professional background in regard to EMF										
yes	66	5.83	5.0	-1.18	.240	64	4.00	4.25	-.18	.857
no	692	6.38	6.0			682	4.02	4.25		

a. High values indicate high number of beliefs about adverse health effects (Min. = 0 scale point, Max. = 16 scale points) or high agreement with items about 'non-scientific beliefs' (six-point scale: 1 = I do not agree at all; 6 = I fully agree).

4 Discussion

The use of electronic devices in our daily life has increased greatly over the past decades. As a consequence, individual exposure to all kind of electromagnetic fields has increased and will grow in the future (Würtenberger & Behrendt, 2004). An important source of this increase has been the proliferation of mobile communication infrastructure and services. Some people are

worried about possible adverse health effects of mobile communication and demand clear statements about harmfulness from responsible authorities and science. In fact, there is no definitive scientific answer to possible health effects of EMF exposure nor to effects on human well-being. Scientific research has difficulty in keeping pace with the rapidly increasing progress of technological development. Experts agree that more research is needed, and topics for further study have been identified in several research reviews (e.g., SCENIHR, 2007, pp. 43-44; WHO, 2006). In the meantime, precautionary measures are adopted and debated (e.g., Foster *et al.*, 2000; Som *et al.*, 2004). Simultaneously, various sites on the World Wide Web claim that there is clear scientific evidence for the harmfulness of EMF and that more severe exposure limits are needed immediately. People are confronted with this mix of contradictory information and have to form their own understanding of the uncertainty in regard to possible adverse health effects. In this context, lay-people likely develop their own mix of beliefs about mobile communication health effects. The present study explored the prevalence of commonly found health beliefs as well as their relation to risk perception or health concerns.

4.1 People's General Health Concerns in Regard to Mobile Communication

Generally, the results showed that mobile communication evokes less concern than air pollution or ultraviolet rays. The concerns are comparable with respondent's concerns about EMF emitted by power transmission lines. These results are in line with previous studies (e.g., European Commission, 2007; Ruddat *et al.*, 2005). Only about a third of the respondents in the present study reported that they are not worried about mobile communication. In summary, a considerable number of citizens reported health concerns. Authorities and mobile communication providers should be aware of these facts when evaluating current information strategies and when thinking about new risk communication approaches. Recent studies found evidence that health concerns or prior beliefs influence and polarize further information processing (e.g., Thalmann & Wiedemann, 2006). Therefore, worried readers may experience confirmatory bias - that is accepting information that fits prior beliefs while rejecting information that does not fit prior beliefs (Cvetkovich *et al.*, 2002; Poortinga & Pidgeon, 2004; White *et al.*, 2003) - and increase their risk perception. The reported health concerns raise the question of what

kinds of concrete health beliefs the general population holds and whether they are related to health concerns.

4.2 People's Health Beliefs about EMF Emitted by Mobile Communication

Although scientific evidence cannot provide definitive answers to the statements presented, a considerable number of participants felt that they were able to judge the correctness of the statements. The pattern of answers showed that about two third of the respondents believed in the phenomenon of electromagnetic hypersensitivity (statements 2 and 4). The health belief-items also included some precautionary statements: The demand for limiting mobile phone usage among children and young people for health precaution reasons (statement 5) was wide supported. In contrast, warning stickers on cell phones (statement 20) were considered reasonable by only a third of the respondents. Agreement with items that referred to the harmfulness of radiation properties showed large variation.

To sum up, the prevalence of health beliefs varies considerably, but the feasibility of a one-dimensional Mokken scale suggests that there is a structure connecting these beliefs. People can be characterized in regard to the amount of health beliefs they hold about RF and health. The constructed scale also revealed that the extent of people's health beliefs differs significantly in regard to gender, age, self-reported and heard EHS. The amount of health beliefs is strongly related to found health concerns. In addition, health concerns and health beliefs seem to be related to non-scientific beliefs (cf. Sjöberg & af Wahlberg, 2002). The correlations found suggest that it might be difficult for risk communicators to persuade concerned people with scientific arguments, such as the results of new studies, about the harmlessness of radiation emitted by mobile communication. Even when the scientific evidence might be convincing, people's beliefs in inexplicable phenomena would still persist and shape their perception. This study showed that one third of the people affected by EHS already applied alternative healing procedures against the experienced consequences of EMF.

Furthermore, the findings, especially the group differences, lead to the assumption that health beliefs are shaped by factors such as knowledge, information processing and personal experiences.

The occurrence of these beliefs triggers the question how these kinds of beliefs are shaped. As outlined above, the available information is confusing and affected by controversies between various interest groups. The evaluation of this information in regard to its relevance and reliability is highly demanding. Therefore, it would not be surprising if people in this context of uncertainty rely on simple heuristics and paid more attention to threatening information (Skowronski & Carlston, 1989; Taylor, 1991) or form their risk evaluation on trust in the responsible actors (Siegrist *et al.*, 2007). Based on this study, it is not possible to draw any conclusion about the shaping process of health beliefs, but the results indicate the importance of policy makers developing a clear understanding of the possible effects of health beliefs on health concerns or risk perception in order to tailor adequate information materials.

4.3 Limitations and Further Research

Some limitations of the presented results and derived interpretations must be addressed. Even though the questionnaire was sent to a random sample, males, high-educated citizens, and people affected by EHS were overrepresented (cf. Leitgeb & Schröttner, 2003; Schreier *et al.*, 2006). In addition, the sample may be affected by a self-selection bias. It is probable that people with a special affinity to the topic were more motivated to return the questionnaire. Therefore, it can be assumed that the respondents were more concerned by radiation emitted by mobile communication than the average. This may have influenced the extent of expressed concerns.

We chose only a subsample of health beliefs found in qualitative interviews. It might be interesting to learn more about the interrelations among these beliefs, to explore how they were shaped and to consider the influences of available information on these processes in experimental settings. In addition, the selected health beliefs were rather general. It might be revealing to focus on specific beliefs in regard to base stations and cell phones. Thereby, one could gain insights as to why base stations evoke more concerns despite the fact that cell phones are more relevant for exposure.

4.4 Conclusion

Authorities and mobile phone providers have to take into account that approximately two third of the Swiss population express at least some concerns about possible health effects related to mobile communication. Despite the lack of scientific evidence, a portion of the citizens are certain that EHS can occur in humans and that EMF emitted by mobile communication can harm humans' health. Health beliefs were shown to correlate with citizens' health concerns. This leads to such questions as how these health beliefs were shaped, whether information available influences these processes and whether existing beliefs can be changed by providing additional information.

Understanding citizens' health beliefs may help in comprehending public responses to existing risk messages and in providing guidance to the development of information materials and strategies. For example, the selection of information may be facilitated, and the need for group-specific information may be clarified.

Chapter V

Biased Confidence in Risk Assessment Studies



Abstract

The present research examined factors that influence laypeople's confidence in the results of risk assessment studies. A 2 (hazard; cell phone, base station) x 2 (study outcome; no risk, risk) x 2 (health effect; well-being, cancer) x 3 (risk perception prior to the manipulation; low, medium, high) design was used. Results showed that participants had more confidence in studies with results that were in line with their prior attitudes compared with studies that were at odds with their prior attitudes. In addition, participants had more confidence in studies showing a risk compared with studies showing no risk. Results suggest that these biases may be one of the reasons why laypeople are concerned about technological risks, even when risk assessment studies indicate that there is a low probability of adverse health effects.

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1 Introduction

Public risk perception influences the acceptance of new technologies (Siegrist, 2000). It is important, therefore, to examine the factors that affect laypeople's perception of risk. For laypeople, the most important source of information about health issues and risks seems to be the news media (Krewski *et al.*, 2006). Past research suggests that the media are more likely to report about studies suggesting that a technology is risky than about studies suggesting that a technology is safe (Koren & Klein, 1991). If laypeople show a similar negativity bias, the public may be overly concerned about technological hazards.

Risk assessments may help people evaluate the risks they face. Since all risks are not equally likely, information is needed to identify those that one should take precautionary measures against. In the present study, we were interested in the degree of confidence that laypeople have in the results of various hypothetical risk assessment studies. We hypothesized that laypeople would have more confidence in studies reporting results that are in line with their prior attitudes than in studies that are at odds with their prior beliefs. In addition, we hypothesized that people without strong positive or negative prior beliefs show a negativity bias. In other words, these people have more confidence in studies indicating risks than in studies indicating no risks. As a consequence, it may be difficult to convince people that they do not need to be concerned about certain technological hazards.

Slovic (1993) has suggested that there is an asymmetry in trust judgments, with trust being difficult to establish but easy to destroy. Results of his study suggested that hypothetical negative events indicating possible mismanagement of a nuclear power plant had far stronger effects on levels of expressed trust than did positive events indicating normal operations. Negative events lowered expressed trust more than positive events increased it. Several possible explanations for this 'trust asymmetry' have been proposed. A body of social psychology studies suggest that negative information triggers a stronger reaction than positive information (Taylor, 1991). A negativity bias would be one explanation for the trust asymmetry principle postulated by Slovic (1993). Another explanation is the confirmatory bias. According to this view, new information is mostly interpreted in such a way that it accommodates already-held convictions. This bias has been demonstrated in stud-

ies suggesting that research reports that confirmed prior beliefs were judged to be of higher quality than reports that did not (Koehler, 1993).

A negativity bias has been demonstrated in a number of studies (Rozin & Royzman, 2001). Based on their review, Rozin and Royzman hypothesized that there may be innate predispositions to give greater weight to negative entities. It has been argued that negative information often has a higher diagnostic value than positive information (Skowronski & Carlston, 1989). Trustworthy behavior, for example, has little diagnostic value because all people sometimes show such behavior. Truly untrustworthy behavior, on the other hand, distinguishes between people or organizations we can rely on and people or organizations we should distrust. Other reasons for a negativity bias are associated with the fact that for most people it is more important to avoid losses than to realize gains (Kahneman & Tversky, 1979), and that negative information is often perceived as less self-serving than positive information. Experimental studies have shown that participants had more confidence in hypothetical scientific results suggesting a danger than in results indicating a low level of risk (Siegrist & Cvetkovich, 2001). In this study, such effects were observed for hazards ranging from electromagnetic fields to food coloring. Similar findings were reported by Poortinga and Pidgeon (2004). They showed that negative events had a greater impact on trust than positive events. For low-risk hazards (pharmaceuticals), the asymmetry was less evident (White & Eiser, 2005). In the case of policies (as opposed to events), the study by White and Eiser showed that positive outcomes had even greater impact than negative ones. The authors concluded that the trust asymmetry observed by Slovic (1993) may have been accentuated by the fact that nuclear power was the focal hazard.

New information is often interpreted so that it meshes with already-held beliefs. Opponents and supporters of a technology, for example, drew opposite conclusions from a non-catastrophic accident (Plous, 1991). For supporters, it was a proof that the safeguards worked, whereas opponents focused on the incident and concluded that chances of an accident were greater than previously assumed. The interpretation of positive or negative information about a hazard may be shaped by prior attitudes. For example, prior attitudes were shown to moderate the effect of message valence on trust (White *et al.*, 2003). Participants had more confidence in messages that were in line with their prior attitudes. White *et al.* (2003) concluded that prior attitudes, and

not a negativity bias, is the reason that participants had greater trust in negative than in positive messages about hazards. Compared to individuals who trusted the nuclear power industry, those who distrusted it exhibited less trust following both bad and good news (Cvetkovich *et al.*, 2002). Overall, the results of these studies suggest that people may have negative prior attitudes toward many hazards and, as a result, people may have more trust in negative information. Therefore, a confirmatory bias and not a negativity bias may be the reason that people have more confidence in messages indicating risks than in messages indicating no risk.

In the studies reviewed, negativity bias and confirmatory bias were examined for hazards associated with nuclear power, gene technology, pharmaceutical companies and food additives. These hazards can be characterized as non-voluntary risks. In the present study, we examined the effect of information valence and prior attitudes on confidence in a risk assessment study related to a voluntary risk (cell phone) and a non-voluntary risk (base station). In 2003, a Dutch study reported that UMTS base station-like exposure may result in a reduction in well-being (Zwamborn *et al.*, 2003). This study, labeled the TNO study, received wide press coverage in various European countries and fueled public concern about possible adverse effects of base stations. The reliability of the TNO study was debated within the scientific community, however. A Swiss group attempted to replicate the study, but no short-term effect of UMTS base station-like exposure on well-being was found (Regel *et al.*, 2006). The media reported the results of this new study, but they often mentioned that the contrary results of the Dutch study still stood. This anecdote illustrates the difficulties journalists and other laypeople may have in interpreting the results of risk assessment studies.

In the present research, we examined how laypeople respond to studies suggesting that cell phones or base stations are associated with various health risks, and how laypeople respond to studies indicating no such health effects. We hypothesized that both the valence of the study outcome as well as prior attitudes influence confidence in risk assessment results. More specifically, we hypothesized that prior attitudes would shape people's confidence in the outcome of a risk assessment. We anticipated that people would have more confidence in studies that confirm their prior beliefs than in studies that are at odds with prior beliefs. Furthermore, we expected to observe a negativity bias. Participants who perceived cell phones or base stations as a medium risk

were expected to have more confidence in negative study results than in positive study results. These participants cannot use their prior attitudes in evaluating the message. As a result, they should show a negativity bias. We expected that negativity bias and confirmatory bias are particularly powerful when the hazard is non-voluntary (base station) and when the risk is severe (cancer), compared with a situation in which the hazard is voluntary (cell phone) and the risk is less severe (well-being).

2 Method

2.1 Materials and Procedure

A 2 (hazard; cell phone, base station) x 2 (study outcome; no risk, risk) x 2 (health effect; well-being, cancer) x 3 (risk perception prior to the manipulation; low, medium, high) design was used. Data were analyzed by analysis of variance (ANOVA). For planned comparisons, *t*-tests were computed.

Participants received an initial questionnaire that asked them to assess perceived risks associated with either cell phones or base stations, depending on the condition. The question read: *“How do you assess the health risks associated with the use of cell phones (operation of base stations)?”* The possible answers ranged between 1 (no risk at all) and 7 (very high risk). After that, participants read a text describing a hypothetical risk assessment research study. Participants then were asked to indicate their level of confidence in the results of the study and to answer some knowledge questions related to cell phone use. Confidence in study results was measured with the following questions: *“How much confidence do you have in the study results?”* The possible answers ranged between 1 (absolutely no confidence) and 7 (complete confidence). Finally, participants answered standard socio-demographic questions.

After responding to the short questionnaire, participants read a hypothetical story about the results of an international study. Three factors were manipulated. The exposure source was either a cell phone or a base station. The cell phone is a voluntary and controllable hazard, whereas the base station is an involuntary and uncontrollable hazard. The second factor was related to the study outcome. The study was described as either having found an asso-

ciation between exposure to cell phones (base stations) and possible health risks or as not having found such an association. For the third factor, possible health risks were described as either negative impacts on well-being (headache, sleep disturbance, disruption of concentration) or increased risk of getting cancer.

Participants first received some general information about cell phone radiation. Then they received one of eight different information vignettes. The following text was used in the cell phone, no risk and well-being condition:

“A recent international study by the University of Oxford provided new knowledge about the impact of the electromagnetic fields of cell phones on well-being. In this research, 2,375 subjects from various European countries participated. Results of this study show that electromagnetic fields do not cause headache, sleeping disorders or disruption of concentration. Therefore, well-being is not impaired.”

The hazard was manipulated so that either cell phone or base station was used. To manipulate study outcome, we either mentioned that electromagnetic fields cause health effects or that electromagnetic fields do not cause health effects. Health effects were manipulated so that either effects related to well-being or to cancer were mentioned. The cancer, base station, risk version read:

“A recent international study by the University of Oxford provided new knowledge about the impact of the electromagnetic fields of cell phones on well-being. In this research, 2,375 subjects from various European countries participated. Results of this study show that persons who lived for the last 10 years in an area with high exposure to base stations had cancer more often compared with people living in area with relatively low exposure. Based on these results, one can expect that a long term exposure to electromagnetic fields emitted by base stations results in a increased risk of developing cancer.”

After the experiment, participants were informed that the study described in the questionnaire was fictitious.

2.2 Participants

The data for the present study were collected between November and December 2006 at different universities and at a grammar school in the German-speaking part of Switzerland. Data collection lasted about ten minutes and took place at the beginning of class lectures. Each participant was randomly assigned to one of eight conditions.

A total of 670 students participated in the study (398 females, 256 males; 16 students did not report the gender). Participants' mean age was 22.7 years ($SD = 6.1$). All but 13 respondents owned a cell phone. Participants were asked about their frequency of usage. Seventy percent ($n = 465$) of the respondents reported using their mobile phones several times a day, 27% ($n = 182$) several times a week, 1% ($n = 8$) about one time a month, and 2% ($n = 13$) never. Two participants did not answer this question.

3 Results

Based on their prior attitudes, participants were classified as being in one of three risk perception groups, low (responses 1-3, $n = 215$), medium (response 4, $n = 160$) and high (responses 5-7, $n = 294$). As mentioned above, the data were submitted to a 2 (source; cell phone, base station) \times 2 (study outcome; no risk, risk) \times 2 (health effect; well-being, cancer) \times 3 (prior risk perception; low, medium, high) analysis of variance. We found a significant main effect for outcome ($F(1,645) = 11.12, p = .001$). Participants had more confidence in study results suggesting negative health effects of cell phones or base stations than in study results showing no such effects. The main effects of source ($F(1,645) = 0.34, ns$), health effect ($F(1,645) = 0.00, ns$), and prior risk perception ($F(1,645) = 0.02, ns$) were not significant. The main effects were qualified by a significant prior attitude \times outcome interaction ($F(2,645) = 46.12, p < .001$). Participants with a low level of perceived risk had more confidence in the study that found no risk, whereas participants with a high level of perceived risk had more confidence in the study indicating that cell phone or base station radiations are risky. All other interaction terms were not significant ($p > .19$). Means and standard deviations are shown in Table 5.1. To facilitate the interpretation of the interaction between

prior risk perception and study outcome, the results depicted in Figure 5.1 ignore the variables health effect and source.

For each of the three levels of prior risk perception, planned comparisons were conducted to examine whether risk and no risk information produced different levels of confidence. Results of one-tailed tests are presented because we have hypothesized that the negativity bias should be dominant in the medium risk perception group, and that the confirmatory bias should be dominant in the other two groups. Participants in the group with a low level in prior risk perception had significantly more confidence in results showing no risk compared with results indicating risks, $t(213) = 4.39, p < .001$. For the participants with a medium level of prior risk perception, a significant difference was also observed, $t(158) = 1.90, p = .03$. Results suggest that participants had more confidence in results reporting risks compared with results reporting no risks. The same difference was observed for participants who had a high level of prior risk perception, $t(292) = 9.90, p < .001$.

Table 5.1. The influence of EMF source, study outcome, health effect, and prior attitudes on confidence in study results. Means and standard deviations are shown^a

	Cell phones		Base Stations	
	No risk	Risk	No risk	Risk
Well-being				
Low risk perception	4.79 <i>n</i> = 24 (1.18)	3.58 <i>n</i> = 36 (1.11)	4.72 <i>n</i> = 25 (1.49)	3.78 <i>n</i> = 27 (1.37)
Medium risk perception	4.16 <i>n</i> = 25 (1.28)	4.57 <i>n</i> = 14 (1.34)	3.78 <i>n</i> = 23 (1.41)	4.22 <i>n</i> = 18 (0.88)
High risk perception	3.88 <i>n</i> = 32 (1.21)	4.89 <i>n</i> = 35 (1.11)	3.43 <i>n</i> = 35 (1.34)	5.15 <i>n</i> = 39 (1.04)
Cancer				
Low risk perception	4.36 <i>n</i> = 22 (1.47)	4.07 <i>n</i> = 27 (1.24)	4.59 <i>n</i> = 27 (1.39)	4.07 <i>n</i> = 27 (1.04)
Medium risk perception	4.06 <i>n</i> = 18 (1.11)	4.52 <i>n</i> = 21 (0.93)	4.23 <i>n</i> = 22 (1.02)	4.32 <i>n</i> = 19 (1.16)
High risk perception	3.55 <i>n</i> = 44 (1.25)	4.86 <i>n</i> = 35 (1.26)	3.44 <i>n</i> = 36 (1.36)	4.87 <i>n</i> = 38 (0.99)

a. Ratings made on a seven-point scale: 1 = absolutely no confidence; 7 = complete confidence

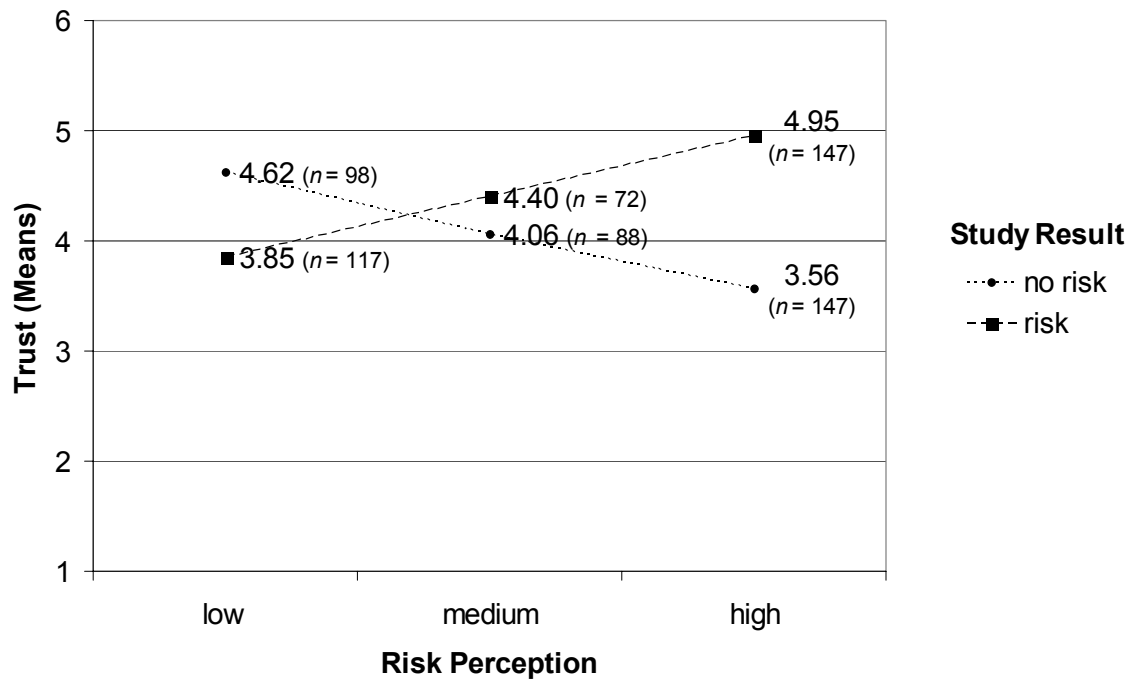


Figure 5.1. The influence of study outcome and prior attitudes on confidence in study results

4 Discussion

It is commonly argued that people should be informed about possible health risks so that they will be well equipped to make informed decisions. Past research has suggested, however, that people may be biased toward negative information (Siegrist & Cvetkovich, 2001). People seem to have more confidence in studies indicating that a technology is risky compared with studies indicating that a technology is not risky. This finding has been challenged recently. It has been shown that, under some circumstances, positive information can have a stronger impact on trust than negative information (White & Eiser, 2005). Furthermore, it has been shown that prior attitudes influence people's confidence in negative and positive information (Cvetkovich *et al.*, 2002). White *et al.* (2003) found that prior attitudes influence confidence, but they did not find a main effect for a negativity bias that can be observed when controlling for prior attitude.

In the present study, we informed participants about hypothetical risk assessment studies associated with base stations or cell phones. Results showed that prior attitudes had a strong effect on participants' confidence in study results. Participants concerned about negative health effects of cell phones or base stations had more confidence in study results demonstrating negative health effects than in studies showing no such effects. Participants who perceived the risk of cell phones and base stations as rather low had more confidence in the results that were in line with their convictions. In other words, they had more confidence in study results showing no health effects, and they had less confidence in study results demonstrating negative health effects.

In addition to the interaction effect, we also observed a significant main effect for study outcomes. Participants had more confidence in studies with negative outcomes than in studies showing no such risks. Results of our study show that even when controlling for prior risk perception, there is still a negativity bias. This finding contrasts with the findings of White *et al.* (2003), who concluded that prior attitudes and not a negativity bias was the reason that participants had greater trust in negative than in positive information about hazards.

Planned contrasts showed that participants who, prior to the experiment, perceived neither risks nor no risks associated electromagnetic fields assessed the study indicating risks as being more trustworthy than the study indicating no risks. This result suggests that the negativity bias is especially powerful when people do not have clear risk perceptions related to a hazard. This asymmetry between positive and negative information may be one of the reasons why laypeople are concerned about technological risks, even when risk assessment studies indicate that there is a low probability of a risk (Macri & Mullet, 2007; Siegrist *et al.*, 2005).

Results of the present study did not support our hypothesis that confirmatory bias and negativity bias may be different for voluntary and non-voluntary risk. Whether the hazard was controllable (i.e., cell phone) or not controllable (i.e., base station) did not influence confidence in study results. The type of outcome, psychological or physiological health effects, also had no influence on participants' confidence in study results. It is likely, there-

fore, that we can expect to observe similar results for a broad range of hazards and study outcomes.

Some limitations of the present study should be addressed. In line with most previous studies (Cvetkovich *et al.*, 2002; Siegrist & Cvetkovich, 2001; White & Eiser, 2005; White *et al.*, 2003) we measured confidence in study results using a single item. Single item measures tend to have low reliabilities. As a result we may have underestimated the effects of negativity bias and confirmatory bias on the processing of risk assessment information.

A question not addressed by the present research is how the prior attitudes that influenced confidence in the study results were formed. One could speculate that, among other factors, negativity bias influences people's risk perception before they have developed strong prior attitudes towards a hazard. Once people have strong attitudes, the confirmatory bias may be much more important than the negativity bias. Future research may wish to use longitudinal research designs to further examine the impact of negativity bias and confirmatory bias on people's risk perception.

If there is a need to inform the public so that it is not overly concerned about a new technology, the simple publication of risk assessments will not be convincing to apprehensive citizens. Without trust the public belief that the industry is truly concerned about public health. Even studies showing that a technology poses no risk will not be interpreted in favorable ways by most citizens. Establishing a high level of trust in science and in industry is a prerequisite to public acceptance of and reliance on the outcomes of risk assessment studies.

Chapter VI

Implicit Attitudes toward Nuclear Power and Mobile Phone Base Stations: Support for the Affect Heuristic



Abstract

The implicit association test (IAT) measures automatic associations. In the present research, the IAT was adapted to measure implicit attitudes toward technological hazards. In Study 1, implicit and explicit attitudes toward nuclear power were examined. Implicit measures (i.e., the IAT) revealed negative attitudes toward nuclear power that were not detected by explicit measures (i.e., a questionnaire). In Study 2, implicit attitudes toward EMF (electro-magnetic field) hazards were examined. Results showed that cell phone base stations and power lines are judged to be similarly risky and, further, that base stations are more closely related to risk concepts than home appliances are. No differences between experts and laypeople were observed. Results of the present studies are in line with the affect heuristic proposed by Slovic and colleagues. Affect seems to be an important factor in risk perception.

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1 Introduction

Many researchers have examined the factors that determine perceptions of risk (Krimsky & Golding, 1992). The psychometric paradigm is probably the most popular research approach used to identify factors that influence the perception of various hazards (Fischhoff *et al.*, 1978; Slovic, 1987). In this approach, participants use a variety of rating scales to evaluate a set of hazards. For example, participants may evaluate each hazard for severity of consequences (how likely is it that the consequences will be fatal). Most of these studies present a very heterogeneous set of hazards, ranging from alcoholic beverages to nuclear power. On the surface, the psychometric paradigm appears to be a highly analytical approach to understanding why people perceive various hazards differently, thus leading to a variety of criticisms (Siegrist, Keller *et al.*, 2005; Sjöberg, 1996). Recently it has been suggested that affect may be an important factor in risk perception. In the present research, a new measurement method, designed to assess implicit attitudes, is used to examine the affect-related component of risk perception.

1.1 Affect and Risk Perception

Psychological research on influence has employed the concept of attitudes to explain public reactions toward new technologies (Frewer *et al.*, 2004). Attitudes are evaluations of objects in an environment, and they present a summary evaluation of an object (Ajzen, 2001). These evaluations can vary from positive to negative, and they are experienced as affect. Typical evaluative dimensions are good-bad, pleasant-unpleasant, or likable-dislikable (Ajzen, 2001). Attitudes not only include affective evaluation, but also a cognitive component and a behavioral component. The present research focuses on the affective component.

In recent years, several authors have suggested that affect may play an important role in risk perception. Loewenstein and colleagues (Loewenstein *et al.*, 2001) introduced the ‘risk as feelings’ model. A similar approach, combining affect and risk perception, is the affect heuristic proposed by Slovic and colleagues (Finucane *et al.*, 2000; Slovic *et al.*, 2002; Slovic *et al.*, 2004). This theoretical framework distinguishes two modes of thinking, the experiential system and the analytical system. The analytical system re-

lies on probabilities, logical reasoning and evidence. The experiential system relies on images, metaphors and narratives. Laypeople rely on trust when making judgments of risks and benefits, when personal knowledge about hazards is lacking (Siegrist & Cvetkovich, 2000). Research suggests that laypeople possess little knowledge about general science questions (Miller, 1998). Therefore, it seems plausible that laypeople may use the experiential system and not the analytic system when they are asked to evaluate a set of hazards.

Slovic and colleagues (Slovic *et al.*, 2004) suggested that the dread risk factor identified in psychometric studies could be interpreted as evidence of risk as feelings. Further support for the hypothesis that affect determines perceived risks is provided by a study by Alhakami and Slovic (1994). They found that the inverse relationship between perceived risk and perceived benefit was linked to feelings about a hazard. Slovic and colleagues use ‘affect’ as it is employed in the concept of attitude (e.g., Ajzen, 2001), to mean overall degree of positivity or negativity toward the attitude object.

Implicit attitude measurements differ from explicit attitude measurements in that responses are not consciously controlled. Spence and Townsend (2006) utilized the Go No-Go task to examine implicit evaluations of GM foods. In a sample of well-educated people, they observed positive implicit attitudes toward GM foods, and neutral explicit attitudes. Results of this study suggest that implicit measurements may provide additional insights for a better understanding of laypeople’s risk perception.

1.2 The Implicit Association Test (IAT)

Previous research examining laypeople’s risk perceptions has relied almost exclusively on explicit methods of measurement. Explicit measures depend on introspective access to the association strengths that are measured (Greenwald *et al.*, 2002). Evidence indicates, however, that such access may not be available (Nisbett & Wilson, 1977). Furthermore, respondents may not be willing to honestly answer questions. It is the goal of implicit measurement strategies to overcome the problems associated with directly asking people about their attitudes toward an object.

Recently, a new measurement method for assessing implicit attitudes was introduced (Greenwald *et al.*, 1998). The implicit association test (IAT) measures implicit attitudes by assessing the response latencies of automatic evaluations. Thus, the IAT is a method that indirectly measures strengths of associations between concepts and evaluative attributes (Greenwald & Nosek, 2001). Even though the IAT was introduced only recently, it already has been used in many studies. The IAT was used, for example, to measure spider phobia (Teachman & Woody, 2003), anxiety (Egloff & Schmukle, 2002), consumer attitudes (Maison *et al.*, 2001), and racial prejudices (Greenwald *et al.*, 1998). Results of these studies strongly support the reliability and validity of the IAT attitude measures (Cunningham *et al.*, 2001; Greenwald & Nosek, 2001). A substantial body of research supports the IAT's convergent and discriminant validity. However, self-report measures and IAT measures are often only weakly correlated (Greenwald & Nosek, 2001). This result is in line with the conclusion that the IAT measures constructs that are often distinct from self-report measures.

Results of the research examining racial prejudice (Greenwald *et al.*, 1998) suggest, for example, that White participants had different implicit attitudes toward Blacks than toward White racial categories. Participants responded faster to the White + pleasant combination than to the Black + pleasant combination. This difference can be viewed as an attitudinal preference for White over Black. In the research examining attitudes toward race, a divergence between implicit and explicit measures was observed (Greenwald *et al.*, 1998). This result suggests that the IAT may measure attitudinal differences not captured by the more traditional explicit methods (e.g., questionnaires). IAT results, however, cannot determine whether Whites are more associated to pleasant words than Blacks or whether Blacks are less associated to pleasant words than Whites. This is an important limitation of the IAT.

There is some evidence that IAT effects are based on affect. An fMRI study found a significant correlation between the strength of amygdala activation and the race IAT effect (Phelps *et al.*, 2000). The amygdala was more activated when white participants viewed photographs of black faces than when they viewed white faces. The amygdala seems to be important for emotional learning and evaluation.

1.3 The Present Studies

The present research utilizes the IAT to measure attitudes toward hazards. To the best of our knowledge there exists only one study in which the IAT has been used to measure implicit attitudes toward a technological hazard (Montijn-Dorgelo & Midden, 2004). One goal of the present research is to compare explicit and implicit measures. Results may show whether implicit measures reveal additional insights not provided by explicit measures. In addition, we test the hypothesis that the ‘dread’ dimension in the psychometric paradigm is related to affect. Results of past research suggest that, under time pressure, the experiential system is more important than the analytical system (Finucane *et al.*, 2000). The IAT requires participants to respond very quickly, leading to experiential processing. It was expected, therefore, that the IAT effects would be related to the positioning of hazards on the dread dimension in the psychometric paradigm.

2 Study 1: Implicit Attitudes toward Nuclear Power

In Study 1 implicit and explicit attitudes toward nuclear power were examined. Nuclear power is perceived as a dreadful hazard (Siegrist, Keller *et al.*, 2005). It was hypothesized, therefore, that even people who are indifferent to or in favor of nuclear power do not associate positive affect with this technology. Consequently, implicit measures may reveal negative attitudes toward nuclear power that are not detected by traditional questionnaire measures. We hypothesized that participants will show positive IAT effects. In other words, we expected that negative attributes are more strongly associated with nuclear power and that positive attributes are more strongly associated with hydroelectric power.

2.1 Method

2.1.1 Participants

One hundred and sixty students from the University of Zürich and the Swiss Federal Institute of Technology participated in the Study (91 males, 69 females). The participants’ mean age was 23.7 years ($SD = 2.7$).

2.1.2 Procedure

Participants completed a questionnaire that measured explicit attitudes toward nuclear power and toward hydroelectric power. Participants also responded to questions not related to the present research. After completing the paper and pencil questionnaire, participants were seated in front of a portable computer. Participants responded via the computer keyboard. Results of recent research suggest that the order of presentation of IAT and self-report measures does not affect the outcome of either measure (Nosek *et al.*, 2005).

2.1.3 Questionnaire

Participants answered two general questions assessing their attitudes toward nuclear power and hydroelectric power (e.g., “Overall, how do you assess nuclear power?”). Five response alternatives were provided: Very negative, negative, undecided, positive, and very positive. Two questions measured participants’ explicit attitudes toward new nuclear power plants in Switzerland (“There are several nuclear power plants in Switzerland. These plants must be replaced in the near future. What is your position with regard to the proposition to replace the old plants with new plants?” “If there were a referendum next weekend on the construction of a new nuclear power plant in Switzerland, how would you vote?”). The possible answers were “I’m opposed,” “Undecided,” and “I’m in favor.”

2.1.4 The IAT

The IAT is a task in which participants classify words or pictures into subordinate categories. The method described by Greenwald *et al.* (1998) was used, adapted to measure implicit attitudes toward nuclear power. The IAT is a relative measure. In the present study, automatic associations with nuclear power were measured relative to automatic associations with hydroelectric power.

Participants responded to photographs depicting nuclear power plants or photographs associated with hydroelectric power and to positive or negative words representing evaluative attributes. Participants used separate computer keys to indicate whether the photograph belonged to the nuclear power plant category or the hydroelectric power category. The same two keys were used to indicate whether a word was good or bad.

Each stimulus was presented in the center of the computer screen. Participants pressed the left key (“e”) or the right key (“i”) to categorize the stimulus as quickly as possible. The seven Blocks of the IAT are described in Table 6.1. In Block 1, participants practiced the target-concept discrimination (photographs related to nuclear power and hydroelectric power). In Block 2, participants practiced the evaluative attributes discrimination (words related to the positive and negative categories). Blocks 3 and 4 consisted of the first relevant trials. Both attributes and target-concepts were randomly selected and displayed. They were assigned to the same keys as in the preceding two blocks. In Block 5, key assignments for the target-concepts were switched. Blocks 6 and 7 were complementary to Blocks 3 and 4. The only difference was that, in Blocks 3 and 4, stimuli related to nuclear power and stimuli related to the negative attribute category were assigned the same key; in Blocks 6 and 7, stimuli related to hydroelectric power and stimuli related to the negative attribute category were assigned the same key. The IAT effect is the difference between the average response latency across all trials in Blocks 6 and 7 minus the average response latency in Blocks 3 and 4.

Table 6.1. Trial blocks in the IAT of Study 1

Block	# of trials	Function	Items assigned to key “e”	Items assigned to key “i”
1	16	Practice	Nuclear power photographs	Hydroelectric power photographs
2	16	Practice	Negative words	Positive words
3	16	Test	Nuclear power photographs + negative words	Hydroelectric power photographs + positive words
4	32	Test	Nuclear power photographs + negative words	Hydroelectric power photographs + positive words
5	16	Practice	Hydroelectric power photographs	Nuclear power photographs
6	16	Test	Hydroelectric power photographs + negative words	Nuclear power photographs + positive words
7	32	Test	Hydroelectric power photographs + negative words	Nuclear power photographs + positive words

Presentation of stimuli and registration of responses were controlled by a FileMaker program. The software was run on an Apple PowerBook G3 with Macintosh OS X. Participants used the keys “e” and “i” for their responses. Each stimulus was shown on the screen until the computer registered a correct response. If a participant responded incorrectly, the stimulus remained

on the screen, and a red “X” was displayed until the correct response was given. For each participant, stimuli were randomly selected within each block and presented without replacement.

In Study 1, the paired target concepts were nuclear power and hydroelectric power. Four different photographs related to nuclear power and four different color photographs related to hydroelectric power were utilized. The width of the photographs was approximately 8 cm, and the height varied between 4 cm and 8 cm. Areas of the nuclear power photographs were comparable to the hydroelectric power photographs. The paired attribute dimensions were positive and negative. The four words related to the positive category were “erfreulich” (enjoyable), “sympathisch” (likable), “angenehm” (pleasant), and “gut” (good). The four words related to the negative category were “unangenehm” (unpleasant), “schlecht” (bad), “anstößig” (displeasing), and “unsympathisch” (dislikable).

2.2 Results

2.2.1 Data Processing

The computer recorded response latencies (in milliseconds) and error rates for each trial. The improved scoring algorithm for computing IAT effects was utilized (Greenwald *et al.*, 2003). Trials with latencies longer than 10,000ms were eliminated. Response errors were replaced with the block mean plus 600ms. For each respondent, the following two differences were computed: Mean Block 6 - Mean Block 3, and Mean Block 7 - Mean Block 4. Each difference score was divided by the pooled standard deviation of its associated trials. The average of the two quotients was used as IAT effect. High values mean that nuclear power was more related to negative concepts and less related to positive concepts than hydroelectric power.

2.2.2 Relationship between Implicit and Explicit Measures

Data from the IAT suggested that there was a preference for hydroelectric power over nuclear power ($M = 0.25$, $SD = 0.39$, $95\%-CI = 0.19-0.31$). More specifically, results showed that, for most participants, nuclear power was more closely related to negative concepts than hydroelectric power was related to negative concepts. For the explicit measure “Overall how do you as-

sess nuclear power?” with five responses (1 = very negative, 5 = very positive) a mean of 2.78 ($SD = 0.95$; 95%- $CI = 2.63$ - 2.93) was observed. For the question “*Overall how do you assess hydroelectric power?*” with five responses (1 = very negative, 5 = very positive) a mean of 4.31 ($SD = 0.71$; 95%- $CI = 4.20$ - 4.42) was observed.

The expected relationship between explicit attitudes toward nuclear power and implicit attitudes toward nuclear power was found. The IAT effect was negatively correlated with the general assessment of nuclear power ($r = -.24$, $p = .002$, $N = 160$). Participants who had positive explicit attitudes toward nuclear power showed lower IAT effects compared with participants who had negative explicit attitudes toward nuclear power. The IAT effect, however, was not significantly correlated with explicit attitudes toward hydroelectric power ($r = .03$, ns , $N = 160$).

The IAT effects for participants in favor of, opposed to, and undecided about replacing old nuclear power plants were compared. The data were submitted to a one-way analysis of variance, and the overall test yielded a significant result, $F(2,157) = 5.86$, $p = .004$. The expected pattern of means was observed (see Table 6.2). Using one-tailed tests, planned contrasts indicated that the IAT effect for participants who opposed replacing nuclear power plants ($M = 0.35$) was not significantly higher than that for people who were undecided on that question ($M = 0.25$), $t(157) = 1.39$, $p = .08$. The IAT effect for participants who were in favor of replacing existing nuclear power plants ($M = 0.10$) was significantly lower than that for people who were undecided, $t(157) = 2.04$, $p < .05$. Means depicted in Table 6.2 show that participants who were opposed to replacing existing nuclear power plants, as well as participants who were undecided, showed IAT effects significantly different from zero. In contrast, participants who favored replacing existing nuclear power plants showed IAT effects that did not differ from zero. This latter result suggests that these participants had similar attitudes toward nuclear power and toward hydroelectric power.

Table 6.2. Means and confidence intervals of the IAT effect are shown for different responses to the question “*There are several nuclear power plants in Switzerland. These plants must be replaced in the near future. What is your position with regard to the proposition to replace the old plants with new plants?*”

	Against new plants	Undecided	In favor of new plants
<i>M</i> (<i>SD</i>)	0.35 (0.31)	0.25 (0.42)	0.10 (0.40)
95%- <i>CI</i>	0.27-0.43	0.14-0.37	-0.02-0.22
<i>N</i>	61	54	45

The IAT effects of participants in favor of, opposed to, and undecided toward new nuclear power plants in Switzerland were compared. A one-way analysis of variance yielded a significant result, $F(2,157) = 4.48, p < .05$. The expected pattern of means was observed (see Table 6.3). Using one-tailed tests, planned contrasts indicated that the IAT effect for participants opposed to new nuclear power plants ($M = 0.32$) was significantly higher than that for participants who were indifferent regarding that question ($M = 0.18$), $t(157) = 1.80, p < .05$. The IAT effect for participants who were in favor of new nuclear power plants ($M = 0.10$) was not significantly different from that for participants who were indifferent, $t(157) = 0.82, ns$. Means depicted in Table 6.3 show that IAT effects were significantly different from zero for participants who were opposed to new nuclear power plants and for participants who were indifferent. Participants in favor of new nuclear power plants showed IAT effects that did not differ from zero.

Table 6.3. Means and confidence intervals of the IAT effect are shown for different responses to the question “*If there were a referendum next weekend on the construction of a new power plant in Switzerland, how would you vote?*”

	Against new plants	Undecided	In favor of new plants
<i>M</i> (<i>SD</i>)	0.32 (0.34)	0.18 (0.41)	0.10 (0.44)
95%- <i>CI</i>	0.25-0.39	0.04-0.32	-0.06-0.26
<i>N</i>	95	33	32

2.3 Discussion

Results of Study 1 suggest that people who are indifferent with regard to new nuclear power plants have either negative implicit attitudes toward this technology, or very positive implicit attitudes toward hydroelectric power. Even participants who were in favor of nuclear power failed to show a preference for this technology relative to hydroelectric power. The negative or neutral implicit attitudes toward nuclear power observed in Study 1 may pose a problem for long-term acceptance of this technology. Based on these results, one might expect that these persons would quickly change their views about nuclear power should another accident in a nuclear power plant occur. Interpreting the results we must not forget that the IAT is a relative measure. We do not know whether participants assessed nuclear power negatively or whether participants assessed hydroelectric power positively.

The findings of Study 1 are in line with a recent interpretation of results observed using the psychometric paradigm. Slovic *et al.* (2004) suggested that the dread dimension may represent affect associated with various hazards. Nuclear power is associated with a higher value on the dread dimension than hydroelectric power (Slovic, 1987). The IAT effects observed in Study 1 support the notion that nuclear power is associated with greater negative affect than hydroelectric power.

3 Study 2: Implicit Attitudes toward Hazards Associated with EMF

Results of psychometric studies suggest that nuclear power is viewed as one of the most dreadful technological hazards (Siegrist, Keller *et al.*, 2005; Slovic, 1987). In Study 2, we used the IAT to measure implicit attitudes toward technological hazards that are viewed as less dreadful. Attitudes toward hazards associated with electromagnetic field (EMF) risks were examined. It was the goal of this second study to measure implicit risk perception. Therefore, instead of the categories bad/good, the categories risky/safe were used in Study 2. In addition, the implicit attitudes of experts and those of laypeople were compared. As a result, the effect of knowledge on implicit attitudes toward EMF hazards was examined.

Results of the research utilizing the psychometric approach suggest that power lines and cell phone base stations do not differ on the dread dimension (Siegrist, Earle *et al.*, 2005; Siegrist, Keller *et al.*, 2005). Therefore, it was hypothesized that implicit attitudes toward power lines and implicit attitudes toward cell phone base stations are similar. Furthermore, it was hypothesized that implicit attitudes toward cell phone base stations are more strongly associated with concepts related to risks than are implicit attitudes toward home appliances. Results of past studies suggest that home appliances are perceived as less dreadful than cell phone base stations (Siegrist, Earle *et al.*, 2005; Siegrist, Keller *et al.*, 2005).

3.1 Method

3.1.1 Participants

Fifty-nine students and lecturers from the University of Zürich and the Swiss Federal Institute of Technology participated in the Study (32 males, 27 females). The participants' mean age was 25.6 years ($SD = 6.6$).

Electrical engineering students and lecturers in electrical engineering ($n = 31$) were labeled as experts. Twenty-nine persons were in the fourth semester at least, and they had attended at least one semester course about electromagnetic fields. Two students were in the second semester of their studies. The students from the University of Zurich, who had no instruction on electromagnetic fields, are labeled as laypeople. The two groups differed considerably in regard to their self-assessed knowledge about health risks related to EMF (1 = low, 5 = high). Experts had a much higher value ($M = 3.29$) than laypeople ($M = 1.89$), $t(57) = 5.66$, $p < .001$.

3.1.2 Procedure

Participants were seated in front of a portable computer, and they responded to two IAT tests. The order in which the two tests were presented was counterbalanced.

3.1.3 The IAT

The IAT test, as described in Study 1, was used. The method proposed by Greenwald *et al.* (1998) was adapted to measure implicit attitudes toward cell phone base stations relative to power lines and relative to home appliances, respectively.

Presentation of stimuli and registration of responses were controlled by the same software that was used in Study 1. The software was run on an Apple PowerBook G4 with Macintosh OS X. Participants used the keys “e” and “i” for their responses. Each stimulus was shown on the screen until the computer registered a correct response. If a participant responded incorrectly, the stimulus remained on the screen and a red “X” was displayed until the correct response was given. For each participant, stimuli within each block were randomly selected and presented without replacement.

In Study 2, one IAT test paired power lines and cell phone base stations as the target concepts. Five different photographs related to power lines and 5 different photographs related to base stations were presented. The other IAT test paired home appliances and cell phone base stations. Five different photographs depicting home appliances, together with the same photographs related to base stations used in the first IAT-test, were presented. All but one photograph was in color. The sizes of the photographs varied between 6 cm x 6 cm and 4 cm x 3 cm.

The paired evaluative attributes were the categories risky and safe. The five words related to the risk category were “gefährlich” (dangerous), “problematisch” (problematic), “schädlich” (harmful), “bedenklich” (critical), and “unsicher” (insecure). The 5 words related to the no risk category were “harmlos” (harmless), “unproblematisch” (unproblematic), “gefahrlos” (safe), “unbedenklich” (inoffensive), and “risikolos” (riskless).

Each stimulus was presented in the center of the computer screen. Participants pressed the left key (“e”) or the right key (“i”) to categorize the stimulus as quickly as possible. The seven Blocks of the two IAT tests are described in Table 6.4. The IAT effect is the difference between the average

response latency across all trials in Blocks 6 and 7 minus the average response latency in Blocks 3 and 4.

Table 6.4. Trial blocks in the IATs of Study 2^a

Block	# of trials	Function	Items assigned to key "e"	Items assigned to key "i"
1	20	Practice	Base station photographs	Power lines photographs
2	20	Practice	Risky words	Safety words
3	20	Test	Base station photographs + risky words	Power lines photographs + safety words
4	20	Test	Base station photographs + risky words	Power lines photographs + safety words
5	20	Practice	Power lines photographs	Base station photographs
6	20	Test	Power lines photographs + risky words	Base station photographs + safety words
7	20	Test	Power lines photographs + risky words	Base station photographs + safety words

a. For the second IAT photographs depicting power lines were replaced by photographs depicting home appliances.

3.2 Results

3.2.1 Data Processing

The computer recorded response latencies (in milliseconds) and error rates for each trial. As in Study 1, the improved scoring algorithm for computing IAT effects was employed (Greenwald *et al.*, 2003). Trials with latencies larger than 10,000ms were eliminated. Response errors were replaced with the block mean plus 600ms. The following two differences were computed: Mean Block 6 - Mean Block 3, and Mean Block 7 - Mean Block 4. Each difference score was divided by the pooled standard deviation of its associated trials. The average of the two quotients was used as IAT effect. High values mean that base stations were more related to risk concepts than power lines or home appliances, respectively.

3.2.2 Implicit Attitudes toward Base Stations

The first IAT examined how strongly power lines were associated with risk concepts and how strongly cell phone base stations were associated with risk

concepts. The IAT effect was not significantly different from zero (means and confidence intervals are depicted in Table 6.5). This result suggests that participants implicitly assessed both hazards as similarly risky. Experts and laypeople did not significantly differ in their IAT effects, $t(57) = 0.43$, *ns*.

Table 6.5. Experts' and lay person's IAT effects for electromagnetic field hazards

IAT effects	Experts ($n = 31$)	Laypeople ($n = 28$)
	<i>M</i> (<i>SD</i>) 95%- <i>CI</i>	<i>M</i> (<i>SD</i>) 95%- <i>CI</i>
Base stations relative to power lines	0.08 (0.31) -0.03 - 0.20	0.05 (0.30) -0.07 - 0.17
Base stations relative to home appliances	0.22 (0.30) 0.11 - 0.33	0.27 (0.25) 0.17 - 0.37

In a second IAT test, cell phone base stations and home appliances were compared. For experts and for laypeople, an IAT effect significantly different from zero was observed (means and confidence intervals are depicted in Table 6.5). Results suggest that for most participants, base stations were more closely related to risk concepts than home appliances. However, the two groups, experts and laypeople, did not differ in their IAT effects, $t(57) = 0.76$, *ns*.

3.3 Discussion

Based on results from other studies (Siegrist, Earle *et al.*, 2005; Siegrist, Keller *et al.*, 2005), it was hypothesized that participants would have similar implicit attitudes toward base stations and toward power lines. In addition, it was hypothesized that participants would have more negative implicit attitudes toward base stations than toward home appliances. Results of Study 2 are in line with these predictions, therefore supporting the notion that affect plays an important role in risk perception.

Experts and laypeople differ in their level of knowledge. However, no significant IAT differences between experts and laypeople were observed. Results suggest, therefore, that affective judgments of risk are independent from more cognitive judgments. Results may further suggest that knowledge may not have an impact on implicit attitudes. In other words, it seems unlike-

ly that implicit risk perceptions can be altered through explicit risk communication strategies that provide knowledge information.

4 General Discussion

Two studies used a new method for measuring implicit attitudes, the implicit association test (IAT), to explore attitudes toward technological hazards. Attitudes toward nuclear power and EMF hazards were examined utilizing the IAT. This technique measures relative strengths of automatic associations between pairs of concepts (Greenwald *et al.*, 1998). Results of the present studies suggest that measuring implicit attitudes may usefully complement data derived from explicit measurement techniques. Based on results from IAT tests, it may be concluded that people have much more negative attitudes toward nuclear power than one might conclude based on explicit measures. The IAT may therefore be a promising technique to provide a fuller understanding of people's perceptions of risk. The IAT will not replace traditional explicit measurement techniques such as questionnaires, but it can be an important supplement.

Recently, Slovic and colleagues (Slovic *et al.*, 2004) suggested that people may use the affect heuristic when they assess the dreadfulness of a hazard. Results of the present studies support this hypothesis. For hazards that are located apart from each other on the dread dimension (e.g., nuclear power and hydroelectric power), IAT effects different from zero were observed. However, for hazards that have similar dread assessments (e.g., cell phone base stations and power lines), no significant IAT effects were observed. In the IAT-task respondents must react very quickly. Therefore, the automatic experiential system is involved, but not the deliberative analytical system. Results of the present research further emphasize the importance of affect in risk perception.

Results of the two studies demonstrated that the IAT can be used to measure attitudes toward hazards. The IAT could be a useful technique to improve our understanding of laypeople's risk perception. However, some limitations of the IAT should be mentioned. The IAT is a relative measure. In other words, implicit attitudes toward nuclear power relative to hydroelectric power were measured. We cannot decide, based on the IAT, whether nuclear

power was more related to negative associations or whether hydroelectric power was more related to positive associations.

In future studies other methods for examining implicit attitudes should be employed (Fazio & Olson, 2003). Implicit measurements such as the Go No-go task (Nosek & Banaji, 2001) can be utilized to measure attitudes toward nuclear power. The fact that these measurement methods can be used to measure implicit attitudes toward nuclear power without a reference technology (e.g., hydroelectric power) is an advantage. In the present studies, the IAT was utilized because this is the measurement method that has been used in most studies focusing on implicit attitudes (Fazio & Olson, 2003). Consequently, the IAT is the method for which the strongest evidence of reliability and validity exist.

Chapter VII

General Discussion and Conclusions



1 Cross-Chapter Considerations

For some people, mobile communication is Janus-faced. On the one hand they enjoy the benefits and the possibilities offered by cell phones, but on the other hand they are confused and concerned about the rumored health effects. Most people can come to terms with these ambiguous evaluations, others are worried enough that they change their user behavior or even actively protest against this technology. In sum, people's perceptions of mobile communication vary from very positive and beneficial to very negative and threatening. Little is known about the processes and cognitive factors that shape these attitudes, but the emerging conflicts, especially around base stations, make plain the need for a better understanding of these aspects.

The present dissertation tried to close this knowledge gap. The project explored people's intuitive understanding of mobile communication and its impact on their perception of the technology. To do this, the 'Mental Model Approach' was adapted to the topic of mobile communication. By means of qualitative and quantitative research steps, two main goals were pursued: First, a map that collects and relates all relevant aspects of the topic was constructed (Chapter 2). Second, the existence and the relevance of people's knowledge and understanding were explored. Knowledge structures, beliefs, knowledge gaps and misconceptions were studied (Chapters 3 and 4). In addition, Chapters 5 and 6 explored the impact of affective components and showed that these aspects deserve further investigation.

The main results of the individual research steps were discussed at the ends of the respective Chapters. The present 'General Discussion' is designed to highlight some additional and global thoughts and to propose further research steps. The factual and methodical insights that were generated are interwoven and difficult to discuss separately. Therefore, four important findings are summarized and discussed in the following paragraphs. At the same time, the chosen methodology will be discussed, and prior methodological critiques will be addressed.

1.1 Mental Models Interviews Are Useful Instruments to Explore the Understanding of a Given Risk or Uncertainty

The mental model interviews with experts and laypeople generated a large number of qualitative insights into the field of mobile communication. The comparisons between experts and laypeople allowed the identification of various differing views, knowledge gaps and misconceptions that might be relevant for risk communication. The qualitative approach facilitated a systemic examination of the problem field. I argue, therefore, that the ‘Mental Model Approach’ goes beyond exploring factual knowledge. Most mental model studies try to explore how people came to their understanding of a given risk and which factual knowledge and understanding is relevant in assessing the nature and magnitude of the risk (Bostrom *et al.*, 1992; Zaksek & Arvai, 2004). In the case of mobile communication, the problem has to do with uncertainty about long-term health effects rather than a confirmed risk (WHO, 2002; Valberg *et al.*, 2007). This point was reflected in the final expert influence diagram. The ‘Technical Aspects’ part of the model represents a traditional mental model influence diagram. The ‘Total of Electromagnetic Radiation’ box replaced the normally targeted ‘risk’ because this parameter is measurable and probably linked to the risk, if there is any. All other boxes and highlighted relations in this part explain how a given exposure is composed. The other two model parts, ‘Individual & Social Aspects’ and ‘Interactions,’ add new aspects to the ‘Mental Model Approach.’ Some of the boxes of these parts explain how an individual exposure is composed, but other boxes reflect elements that contribute to the uncertainty of health effects and people’s confusion about it. For example, the model shows which elements are relevant and discussed among experts (e.g., windows effect, low dose effects) and which actors and factors are involved in the social dynamics of the problem field (e.g., public discussion, personal experiences). This expansion of the ‘Mental Model Approach’ meets halfway Wynne’s (1992, pp. 42) call for paying attention to “the formal contents of scientific knowledge; methods and processes of science; and its forms of institutional embedding, patronage, organization and control.” The additional aspects cannot be linked causally to people’s individual risk perception, but they can serve as a ‘road map’ for further research and may influence research designs beneficially.

1.2 Misconceptions and Lack of Knowledge Can Lead to Unfavorable Base Station Siting Preferences and, Consequently, to more Exposure for the Public

As shown by the results of Chapter 3, most people lack understanding of the interaction patterns between cell phones and base stations, as well as of the resulting RF exposure. The lack of knowledge and the misconceptions of exposure magnitudes may be one reason for people's unfavorable base station siting preferences. More important, the dearth of understanding lulls people into a false sense of security. They feel protected from the base station radiation if the base station is far away, but they completely ignore that, as a consequence, their cell phones exposes them to more intensive fields. From a public health perspective, it is important, therefore, to provide people with adequate information. Hence, for health prevention purposes, a shift of attention by both authorities and the public to EMF emitted by cell phones would be highly desirable. Mobile communication providers are particularly reluctant to communicate precautionary advices for cell phone use because they wish to avoid the notion of a real risk. The avoidance of this topic is probably one reason why the public's attention is mainly directed to EMF emitted by base stations. In addition, the Swiss application of the precautionary principle is to some degree paradoxical. The laws envision only precautionary measures for base stations emissions but not for cell phones - despite the fact that cell phones are known to contribute more to a person's individual exposure.¹ Scientists mainly discuss whether low-level, long-term exposure, as emitted by base stations, might affect human's health. If the uncertainty in regard to such low-level fields leads to precautionary measures, it is in some degree paradoxical that there are not such measures, or at least more public attention, in respect to the stronger fields of cell phones. Suppose that in some years the radiation doses emitted by base stations are shown to cause adverse health effects, the possibility that cell phones do the same is highly

1. It must be clarified that national laws regulate base station emissions (NISV, 1999), while hand devices aren't covered by such additional precautionary measures. Cell phones are produced by international firms and conceived for various markets. They need to met the CENELEC product standard EN SN 50360 (CENELEC, 2001a, b) that is based on the ICNIRP emission standard of 2W/kg (ICNIRP, 1998). For purchase decisions, one can consider the SAR value (Specific Absorption Rate) of a cell phone, which indicates the maximal amount of energy absorbed by the body.

probable. Therefore, the cost-benefits analysis of precautionary advice should be revised under these conditions. In general, more research is needed to reflect the possible (paradoxical) effects that precautionary measures and information campaigns may have on public perception (cf. Barnett *et al.*, 2007; Burgess, 2002, 2007; Wiedermann & Schütz, 2005; Wiedermann *et al.*, 2006).

1.3 Existing Beliefs and Attitudes in Regard to Health Effects of Mobile Communication Need Communicator's Attention

One goal of the present thesis was to learn more about how, according to lay-people's beliefs, EMFs of mobile communication affect human's health. Despite the fact that the best scientific evidence neither shows health effects nor provides causal models to explain them, people seem to perceive concrete risks and to have beliefs about their occurrence. The obtained results indicate that it is important for policy makers to develop a clear understanding of the possible effects of health beliefs on health concerns and risk perception. This is especially clear in light of Chapter 5 and other studies (cf. Frewer *et al.*, 1998b; Thalmann & Wiedemann, 2006), which showed that both existing beliefs and prior attitudes influence and shape information processing. Furthermore, these relations are part of the basic assumption of the 'Mental Model Approach.' Existing beliefs affect the reception and interpretation of any new information. Therefore, new information must be presented in such a way as to be consistent with the levels of understanding that are manifest in the audience (cf. Breakwell, 2001, pp. 342; Morgen *et al.*, 2002). In this way the 'Mental Model Approach' makes it explicit that information processing is not a straightforward, unbiased process.

Another relevant topic is trust and trust building processes, especially with respect to information providing. In trust, Renn (2006, pp. 840) identifies a key question of risk communication: "Do I trust the institutions providing the necessary information, or do I not? If the answer is yes, I am willing to use a balancing approach between risks and benefits and to assign trade-offs between the two. If the answer is -no-, I want zero risk." This statement can be transferred to the case of mobile communication. Indeed, persons affected by a new base station siting project often wish to minimize their exposure, in other words to have zero risk in regard to the base station in question. The severe Swiss emission laws and/or the compliance to them by the mobile

communication providers seem not to be trusted. Likewise, results of a study by Siegrist *et al.* (2003) showed that trust and confidence had a strong impact on the acceptance of a base station in one's vicinity (cf. Poortinga & Pidgeon, 2003; Siegrist, Earle *et al.*, 2005).

In general, mobile communication is perceived as a minor risk compared with other environmental hazards (European Commission, 2007; Ruddat *et al.*, 2005; Schreier *et al.*, 2006). But when it comes to a new base station siting project in one's neighborhood, concerns arise. The genesis of one's concerns probably involves factors like existing beliefs, personal experiences, new information, information processing, trust and social dynamics. In other words, the siting of a new base station would provide an interesting research setting for exploring the relevance and interplay of these factors. The interrelations between trustworthiness and information provision would be especially interesting to investigate. To give an example, the qualitative results of the mental model interviews with base station opponents clearly indicated that poor information provision in the run-up of a new base station siting project (by mobile providers and communal authorities) triggers distrust. The additional lack of knowledge in regard to legal responsibilities, official workflows, and the resulting feeling of powerlessness against the establishment amplify the distrust even more and hamper any further interactions and information exchange.¹ This observation strongly suggests that successful communication has restricted time frames. Responsible authorities and mobile communication providers are well advised to move heaven and earth to avoid losing citizens' trust. There are enough other critical issues that will lead to controversies between the involved parties. Two of those issues might be the societal handling of uncertainty. Here, providers take the perspective that the State set the legislation to ensure public health, and all they can do is following these guidelines. Concerned citizens, in contrast, would prefer a 'Better-safe-than-sorry approach' and the imposition of additional safeguards.

1. Mobile communication licenses are sold by the state and entail for the mobile providers an obligation to assure coverage to the population (FMG, 1997). Therefore, if the providers meet all regulations, the communal authorities must allow the base station. In other words, the actual legislation does not foreseen grassroots democracy in regard to base station siting. This may be difficult to accept, especially for Swiss citizens, who are used to this principle.

1.4 The Insights Obtained May Help to Improve Risk Communication

To support this claim, it is necessary to reflect on the aims of risk communication. Depending on the given topic, risk communication can have various goals. In regard to voluntary risks, such as smoking, prenatal diagnosis, or cell phone use, it may be an aim of responsible authorities to inform people about the nature and magnitude of the risk they are taking in order to enable informed decisions. Informed decisions often means making conscious choices or taking safety measures. Because people's time and attention are limited, communication must concentrate on the most efficient precautions that consumers can take to reduce their risk. In other words, they need to prioritize information according to the likelihood and impact of behavioral changes that would follow from it (Riley *et al.*, 2001). The 'Mental Model Approach' helps to identify the misconceptions that most seriously hamper people's understanding of the given risk. In the case of mobile communication, the most efficient way to reduce one's exposure is a proper handling of one's cell phone. Therefore, the interaction patterns of cell phones and base stations are important to understand.

The original 'Mental Model Approach' includes two steps that are not completed at the moment: Typically, the results of the interviews and the questionnaire are used to develop communications with regard to the decisions people face. These communications are designed to fill the relevant knowledge gaps and correct inaccurate beliefs (step 4). The developed communications are tested and refined by individuals from the target group until the communications are fully understood as intended (step 5). The present thesis did not conceive information material. These two steps have to follow before the usefulness of the obtained insights can be seen as confirmed.

However, the very best information material is useless if it is not noticed by the targeted public. This might be an important problem for mobile communication. The topic is not worrying until a new base station siting project makes people think about the health consequences of EMF. In other words, the information materials are often only noticed when concerns motivate people to look for information. But the framing of a concrete 'threat' may bias people's information search and information processing.

In sum, it is not only important to conceive carefully detailed information materials; but it is also important to consider when and why people are looking for the information in question.

One possibility is to involve people early in base station siting processes. This would offer the opportunity to generate another problem framing, to reveal the necessity of a new base station, and to demonstrate the expected exposure consequences of different siting possibilities. Such participative processes are challenging but worth a try.

A further point for additional research is stressed by Breakwell (2001). He argued that little is known about how mental models are shaped and developed over time and proposed that the social representation theory (Moscovici, 1988) might be useful for the understanding of the genesis and maintenance of shared mental models in regard to hazards. Such understanding would help to better direct differentiated interventions in risk communication. He suggested that identity processes might be related to mental models and deserve consideration in regard to the hazard perception of the targeted audience group.

2 Final Conclusion, Limitations and Additional Suggestions for Further Research

The present research project identified many facets that might be related to one's perception of mobile communication and the associated health risks. The cognitive facets dealt with beliefs, knowledge elements, their underlying structure and intuitive understanding. The affective facets explored the importance of trust and affect in regard to perception of mobile communication. To go a step further, I would propose conceiving study designs that explore cognitive and affective components jointly in order to assess their weight and interplay.

Despite the fact that the mental model methodology provided qualitative insights into the dynamics of the fields and may, therefore, generate ideas for further research, these dynamic were considered only marginally in the present dissertation project. As mentioned above, it would be interesting to explore the social dynamics in a neighborhood when it comes to new base

2. Final Conclusion, Limitations and Additional Suggestions for Further Research

station siting. Beside the trust issue, one could explore how people's perceptions change through sudden involvement, persuasive attempts and peer pressure, occurrence and impact of reported EHS, information seeking behavior, information processing, perception of political responsibility, social amplification and so on. In doing so, one needs to be aware that the social processes involved may be due to the country-specific context.

Beside these specific questions with regard to mobile communication, more general issues were recognized as important. For example, the qualitative lay interviews showed that interview partners held inadequate beliefs concerning the processes of establishing scientific evidence. Two different misconceptions can be observed. On one side, they misjudge the explanatory power of single studies. They ignore the fact that several studies need to show the same pattern of results before an effect is considered to be proven. On the other side, an asymmetrical weighting can be observed. They held the belief that a single study is able to proof the harmfulness of RF, but several studies showing no adverse health effects of RF do not reassure them. The first misconception might be partially triggered by media coverage that usually uses headings like "Study proves that...", which implies strong explanatory power for single studies. The second misconception shares similarities with studies that explore the weighting of negative and positive information (e.g., Siegrist & Cvetkovich, 2001). In addition, the occurrence and relation of people's scientific and non-scientific beliefs might be interesting to study in more detail (cf. Siegrist, Earle *et al.*, 2005; Sjöberg & af Wahlberg, 2002). These topics can be summarized under the working title of 'public understanding of science.' Together with the topics 'communication under scientific uncertainty,' 'public's perception of expert dissent,' and 'integration of cognitive and affective processes,' this topic constitutes the big challenges for further research.

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Curriculum Vitae

Marie-Eve Cousin was born in Lucerne, Switzerland on January 15, 1975. She holds a diploma as primary teacher from the Lucerne State and worked from 1995 to 2005 in this function.

From 1998 to 2005 she studied Psychology, Sociology and Science of Education at the University of Zurich. Her master thesis on 'Prenatal diagnosis in the German part of Switzerland' was completed in 2005 at the Department of Psychology.

From summer 2005 to 2007 Marie-Eve Cousin was employed as a research assistant at the University of Zurich. Since June 2007 she has been employed as a research assistant at the Institute for Environmental Decision (IED), Chair of Consumer Behavior, ETH Zurich. In this function, she is involved in teaching activities and research projects. During her PhD thesis, from summer 2005 to spring 2008, on 'Public's perception of mobile communication and the associated health hazard,' she was supervised by Prof. Dr. Michael Siegrist.

